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A Hypothetical 1000 MW(e) Photovoltaic Solar-Electric Plant

Lockheed Missiles and Space Co, Inc, Huntsville, Ala.

Prepared for

Industrial Environmental Research Lab.-Cincinnati, Ohio

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August 1977

ENVIRONMENTAL IMPACT STATEMENT FOR A HYPOTHETICAL 1000 MW_e PHOTOVOLTAIC SOLAR-ELECTRIC PLANT

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This draft EIS was prepared to assist the EPA in strengthening its inputs to environmental impact statements in the area of new energy developments. The document has no legal significance, and the "proposed action" is entirely hypothetical. The hypothetical plant is 1000 MW_e silicon photovoltaic, located on 52 km^2 of desert near Las Vegas, Nevada. It has a 3-hour storage capacity.

The principal adverse environmental impacts expected relate to the destruction of soil and vegetation on 52 km^2 of desert terrain. Revegetation is expected to be very slow without human assistance. Numerous animals will be displaced temporarily or permanently.

The visual impact of this project will be extensive, and no measures are known to minimize the impact.

There will be no effect on ground water, no thermal pollution, no surface water pollution, no noise pollution, and no effect on local historical, archaeological, and cultural values.

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DISCLAIMER

This report has been reviewed by the Industrial Environmental Research Laboratory, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

The project discussed herein is hypothetical. No plans to install a similar solar generating station anywhere are known to exist. The designation of a specific site in this report does not imply that plans exist to install a solar generating station at the site, or that any previously published construction plans for the site have been revised or are being considered for revision.

FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our healt often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

This report, while dealing with a hypothetical 1000 MW photovoltaic central generating station, is nevertheless a serious attempt to present what a real Draft Environmental Impact Statement for a real plant would look like. Environmental and energy administrators, environmental re-researchers, and local government officials in the U.S. Southwest will find this report useful in appraising the problems, if any, that would accompany construction of such a plant. It will help these personnel to perform the necessary developmental research and prepare public responses in anticipation of construction.

Further information on this subject may be obtained from the Power Technology and Conservation Branch of the Energy Systems Environmental Control Division.

David G. Stephan
Director
Industrial Environmental Research Laboratory
Cincinnati

ABSTRACT

This report constitutes an environmental impact statement (EIS) for a hypothetical facility believed to be similar to the photovoltaic solar-electric plants which will be built some day. All features of this EIS are produced in conformity with the mandates of the National Environmental Policy Act (NEPA), although socio-economic matters are somewhat de-emphasized.

The solar-electric plant is a 1000 MW_e silicon photovoltaic plant employing 50,000 one-axis sun-tracking modules distributed over nearly 52 km^2 of desert terrain without any known potential productivity, near Las Vegas, Nevada. The plant is supplied with three hours of battery storage capacity. The chosen plant design is conservative; environmental effects related to area of land disturbed may be regarded as worst-case estimates. The estimated cost of this plant is $\$1.67 \times 10^9$.

The plant will not require any cooling water, steam water, or any other process water. It will not require cooling towers or stacks. There will be no effect on groundwater, no thermal pollution, no surface water pollution, no noise pollution, and no effects on local historical, archaeological, and cultural values.

The principal adverse environmental effects expected relate to destruction of soil and vegetation on 52 km^2 of desert terrain. Re-vegetation is expected to be very slow without human assistance. Mitigative measures are discussed and proposed. Numerous animals will be displaced either temporarily or permanently by the project as a direct or indirect consequence of loss of vegetative cover and of human activity.

The visual impact of this project will be extensive. Some persons will regard the aesthetic impact as adverse, although others will regard the plant as a tourist attraction.

This report was submitted in fulfillment of Contract No. 68-02-1331 by Lockheed Missiles & Space Co., under the sponsorship of the U.S. Environmental Protection Agency. This report covers a period from 4-1-76 to 7-31-76 and work was completed as of 7-31-76. Editorial revisions were incorporated during February 1977.

EXECUTIVE SUMMARY

HYPOTHETICAL SOLAR-ELECTRIC PLANT
DRY LAKE VALLEY, CLARK COUNTY, NEVADA

(X) DRAFT ( ) FINAL ENVIRONMENTAL STATEMENT

RESPONSIBLE OFFICE: None

1. NAME OF ACTION: (X) ADMINISTRATIVE (Hypothetical)

2. DESCRIPTION OF ACTION: This Draft Environmental Impact Statement was prepared for the Environmental Protection Agency to assist the Agency in its efforts to strengthen its inputs to and review of Environmental Impact Statements in the area of new energy developments. This document has no legal significance. The "proposed action" is entirely hypothetical. The specific site was chosen only because extensive baseline data for it had already been collected in preparation for performing an environmental assessment of a 2000 MW_e coal-fired plant actually proposed for construction at the site.

   This Hypothetical Solar-Electric Plant is a 1000 MW_e (peak) silicon photovoltaic plant employing 50,000 one-axis sun-tracking modules distributed over nearly 52 km^2 of desert terrain without any known potential productivity, near Las Vegas, Nevada. The plant is to be supplied with 3 hours of battery storage capacity. With unlimited storage, the capacity factor could approach 100%; the limited storage corresponds to a capacity factor of less than 50% in conventional terms.

3. (A) ENVIRONMENTAL IMPACTS: The proposed station would:

   (i) Provide 1000 MW_e (peak) of electric power to meet the projected power demands of customers in Nevada and Southern California.

   (ii) Increase the reserve margin of the electric generating capacity of the U.S. Southwest thereby improving the utility industry's reliability and, secondarily, that of the associated Interpool Network.

   (iii) The plant will occupy about 52 km^2 in Dry Lake Valley, 32 km NE of Las Vegas, Nevada. It will cost $\$1.67 \times 10^9$.

   (iv) Construction would be phased over 10 years with portions of the installation going on-line as they are completed. Plant lifetime is estimated to be about 30 years, with phased decommissioning to occur over an additional 5 years.

(v) A construction labor force of about 1000 employees is expected. Only fifty operating personnel are planned.

(vi) The plant will not require any cooling water, steam water, or any other process water. It will not require cooling towers or stacks.

(vii) The effects on regional demographic, socioeconomic, and community characteristics will in general be small and, be overwhelmed by the effects of very rapid projected growth in the Las Vegas urban areas.

(viii) There will be no effect on groundwater, no thermal pollution, no surface water pollution, no noise pollution, and no effects on local historical, archaeological, and cultural values.

(B) ADVERSE ENVIRONMENTAL IMPACTS:

(i) The principal adverse environmental effects expected relate to destruction of soil and vegetation on 52 km^2 of desert terrain. Re-vegetation is expected to be very slow without human assistance. Mitigative measures are discussed and proposed.

(ii) Numerous animals will be displaced either temporarily or permanently by the project as a direct or indirect consequence of loss of vegetative cover and of human activity. Only the Desert Tortoise requires assistance in relocation.

(iii) No endangered or threatened species are further threatened by this project. The Kit Fox and the Desert Tortoise are both on the Nevada list of endangered or threatened species. However, the Kit Fox will relocate without assistance. The Desert Tortoise is not rare or threatened in this region except in urban areas and near highways. Nevertheless individuals would be destroyed were no efforts made to relocate them outside the perimeter.

(iv) The visual impact of this project will be extensive. Some persons will regard the aesthetic impact as adverse, although others will regard the plant as a tourist attraction. No mitigative measures are known to minimize the visual impact at the proposed site, adjacent to U.S. Highway 93 and Interstate Highway 15.

4. ALTERNATIVES TO THE PROPOSED ACTION:

(A) No action
(B) Large power import into the region
(C) Reactivation or upgrading of older plants
(D) Alternative sites
(E) Alternative sources of power (coal fired, nuclear, hydro, advanced)
(F) Closer packing of solar modules
(G) Other solar options
(H) Storage options (none, lead-acid, pumped hydro, hydrogen cycle)

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These persons supplied the basic documentation making possible the entire effort, graciously granted permission for us to quote extensively from the documents, and invested substantial time in furnishing us with additional information beyond the documentation.

The project would have been very much more difficult without the help offered by these individuals particularly, and also those listed in the section entitled "Coordination."

SECTION 1
DESCRIPTION OF THE PROPOSED ACTION

1.1 SUMMARY

The solar energy electrical power station is a hypothetical plant used to assess the environmental impact of a utility size solar power station. The site selected for the plant is typical of the sites currently envisioned for the location of the first solar energy electrical power stations. This site is approximately 32 km northeast of Las Vegas, Nevada (Figure 1-1). A detailed environmental assessment exists relative to the site and will be utilized extensively for background information in this report.

The station is a conceptual design for a photovoltaic plant with a 1000 MW_e (peak) capacity. Operating with a capacity factor of 0.5 due to limited energy storage, the plant would produce approximately 0.88×10^6 MWh/yr. The plant consists of 50,000 one-axis sun-tracking modules, each 17.1 m long, 8.5 m wide, and 10.4 m high and the ancillary equipment needed to interface these arrays with a utility network. For visual perspective, one might compare this generating station to a city of 50,000 small homes laid out on a nearly perfect square grid of 33 m lot lines.

Major system components of the plant include the modules, power conditioning facilities and a power wiring system. Major features associated with the facility will be the switchyard, roads and railroad access, administration buildings, storage buildings, maintenance building and a visitor center. The land area required for the 1000 MW_e plant is approximately 52 km^2 or 5200 hectares.

Each module consists of an assembly of concentrating collectors and silicon photovoltaic cells, and a framework supporting the optical and photovoltaic elements. Approximate weight for the module is 12.7 metric tons

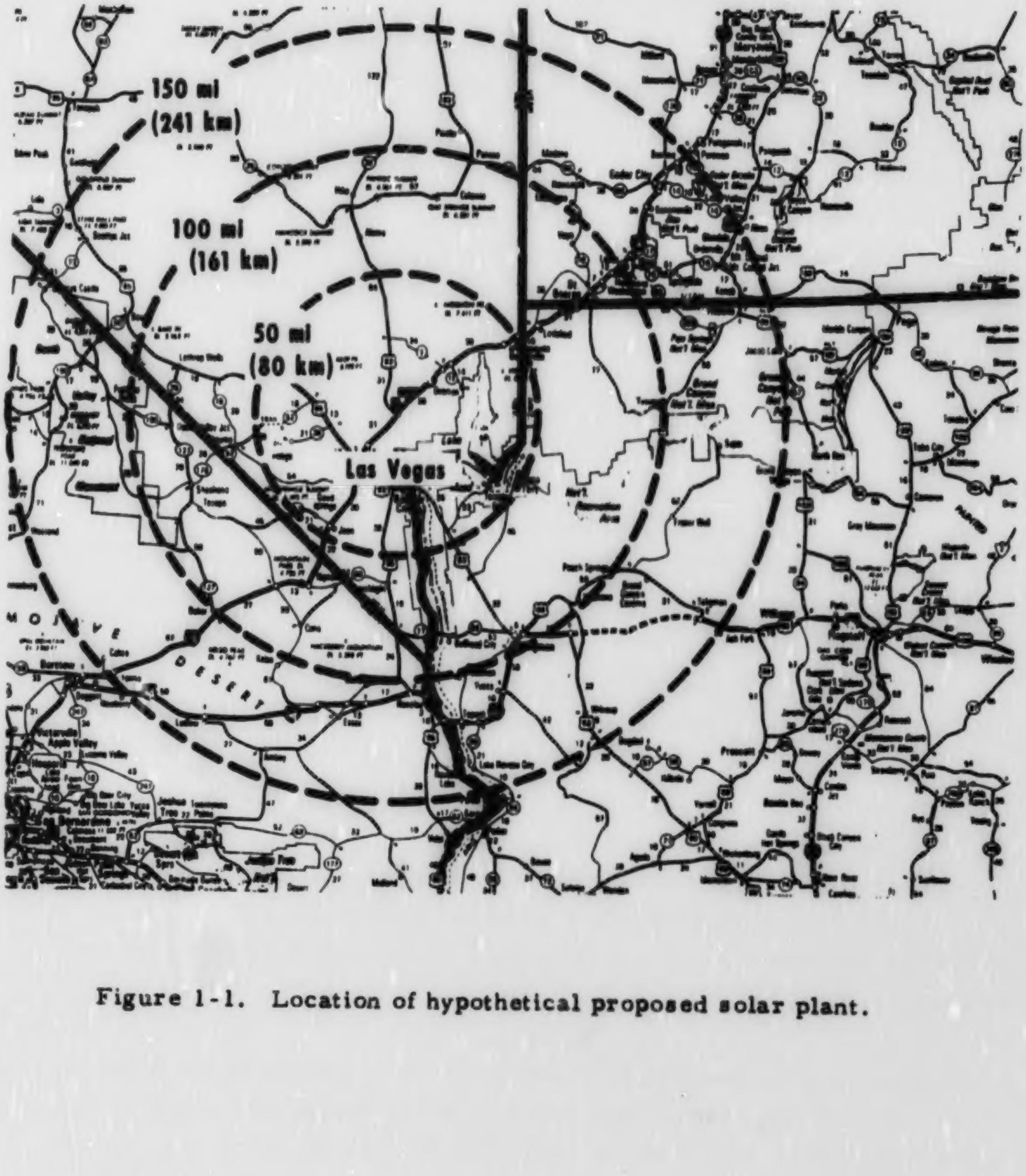

150 mi
(241 km)
100 mi
(161 km)
50 mi
(80 km)
Las Vegas
MOJAVE DESERT

Figure 1-1. Location of hypothetical proposed solar plant.

(MT). The foundation for each is a 12.2 m concrete ring bearing a track upon which the module runs during its daily tracking. The module rotates only about a vertical axis to track the sun, in its westward motion. Each of the 50,000 solar modules is capable of producing 20 kW under normal insolation.

Power from 100 adjacent modules forms the input to each of 500 2 MW power conditioning facilities. Each power conditioning facility includes a regulator, inverter, battery and controller. The controller is governed by a microcomputer that adjusts power output and battery charging and, by means of an SCR switching regulator, tracks the 2 MW group's combined electrical characteristics as a function of temperature and insolation to extract the maximum power available from the arrays.

A 3 hour store of energy in a heated lithium/sulfur battery provides power during periods of cloud cover or, as available, enables plant operation into the early evening hours or early post-dawn morning hours. The dc output of the solar cells (through the regulator) and battery is converted into a 60 Hz sinusoidal wave form compatible with the utility network. The inverter can also be operated as a phase-controlled rectifier to accept and convert for storage of off-peak utility ac energy off the grid. In addition to controlling the operation of the power conditioning modules, the controller also controls the array drive motors and multiplexes data for transmission to the plant's central control room.

The administration buildings are centrally located within the facility boundaries. These house the master control room and offices for facility personnel. Storage buildings are provided for storage of array components, batteries, etc., prior to installation or shipment to the manufacturer for refurbishment. A maintenance building will be utilized to effect repairs and conduct routine maintenance procedures.

North-south service roads every 329 m within the facility will be utilized to service the arrays. Road access to the site will be available via an asphalt paved road from Interstate Highway 15, approximately 1.6 km east of the main entrance to the site. The site access road's junction with the interstate highway is via a "four-leaf clover" arrangement. A visitor's orientation and control center will be located near the interchange to provide for visitor control. An overpass over the main railroad will be provided for uninterrupted highway travel to and from the site.

Module structures will be delivered to the site by the Union Pacific Railroad. A new rail spur will be constructed for this purpose.

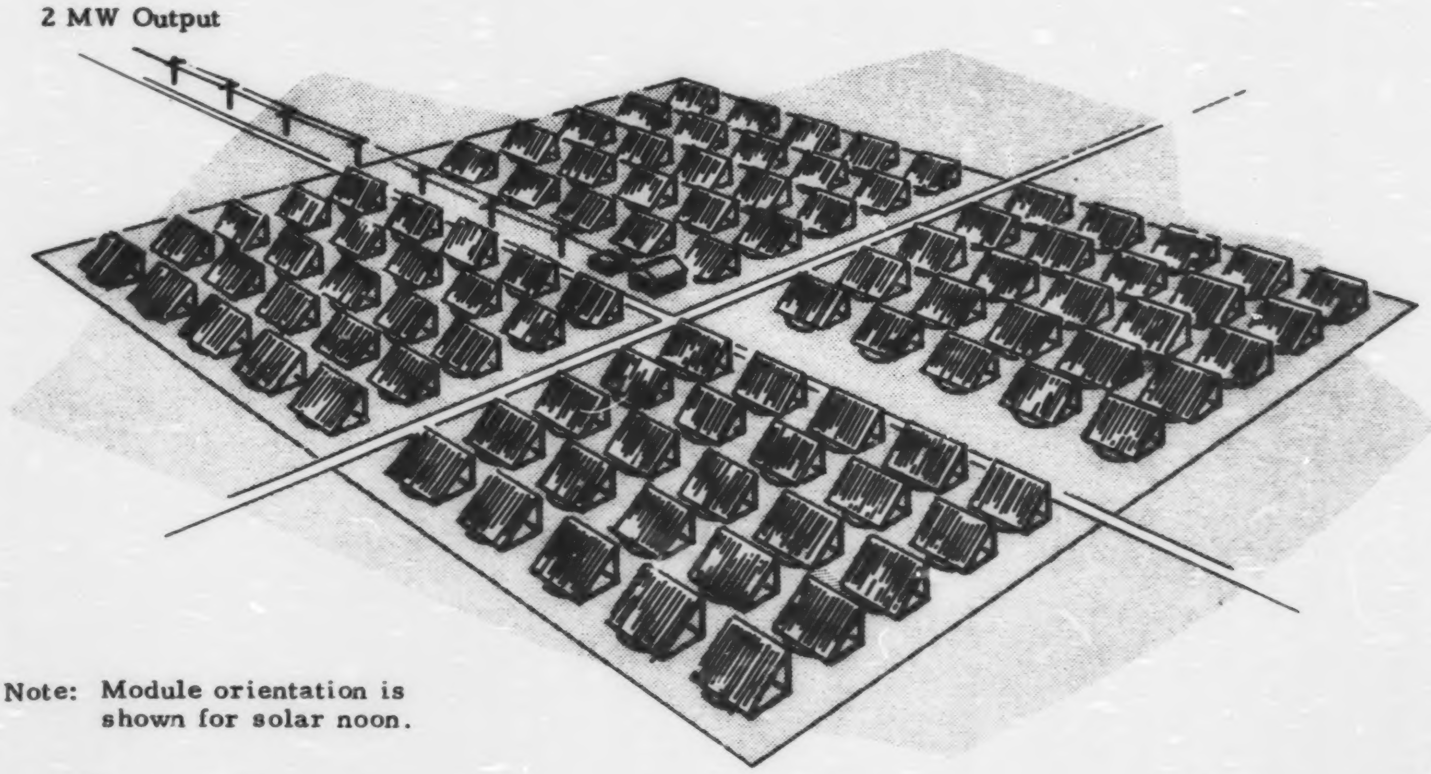
No process water or cooling water is needed. Potable waters for personnel, and minimal quantities of water for maintenance are required. Solar modules are not to be washed; therefore no piping is needed among modules. Occasional washing down of battery house floors is conceivable but can be accommodated by water truck. A chain link fence, barbed wire topped, will enclose the facility. Capacitive probe systems (500) are connected to fence sections for intrusion detection and alarm. Primary access is by gate on the main road. Locked gates are located at selected remote locations.

A visitor control and orientation center is located outside the facility boundaries. The purpose of this center is to provide the interested public with information relative to the operation of the facility. This can include lectures, demonstration models and guided tours of the facility.

1.2 THE INSTALLATION

Description of the Plant Design

The plant utilizes 50,000 power generating modules arranged in groups of 100 modules each. Figure 1-2 depicts a conceptual view of a typical group. Each group has a nominal capacity rating of 2.0 MW, and includes a central power conditioning/storage module comprised of a power regulator, a bank of storage batteries, power inverter, and control system. There are 500 groups whose output is brought to a central plant switchyard by a 34 kV distribution system. There the voltage is stepped up to 230 kV for connection to the utility network by a transformer bank. All switchgear necessary for proper operation of the system is included as well as instrumentation and control



Note: Module orientation is shown for solar noon.

Figure 1-2. Typical 2000 kW solar module group — one of 500.

systems and auxiliaries. (The control switching layout is described later and illustrated in Figure 1-4.)

Solar Array Modules: The dominant feature of the plant is the large array of identical power generating modules spaced on 32.9 m centers in a NS-EW grid pattern, occupying approximately 52 km^2. The design and construction of these modules as given in the following pages is based largely on a design concept prepared for Spectrolab Corporation by Ingenasu Associates (Ref. 1-1). It is believed to be fairly typical of those future photovoltaic power plants which use optical concentration of sunlight.

Figure 1-3 shows a conceptual view of a typical 26 kW module. This module is 8.5 x 17.1 m at the base, 10.4 m high overall, and weighs 12.7 MT. It rotates about a single vertical axis to track the sun. It is equipped with 14 linear collector segments, each made up of 1.2 x 12.2 m primary parabolic trough concentrator and a 12.7 cm x 12.2 m absorber, with the segments arranged side by side on a plane inclined 45 deg from the horizontal.

The primary concentrators are composed of 11 gage (3mm) sheet steel bent into a parabolic trough and retained in this configuration by edge clamps. The inside primary concentrator surfaces are covered with a special plastic reflecting surface material. These reflecting surfaces are metallized second surface reflectors composed of a plastic substrate (probably Scotchcal aluminized acrylic or Sheldahl Ag-fluorocarbon) attached to the concave steel trough surfaces by adhesive applied to the metallized surface. No cover glass is provided over the trough surfaces themselves.

The lifetime of this reflective surface is unknown. Photolytic and thermal degradation of both the plastic substrate and of the adhesive are possibilities which need investigation for two reasons:

1. Failure of these surfaces, requiring replacement of even a few per month, would introduce an enormous maintenance and logistical problem. Field stripping of deteriorated plastic, solvent wash to remove residual adhesive from the troughs, and field application of new reflective material, seem to us to be quite impractical.

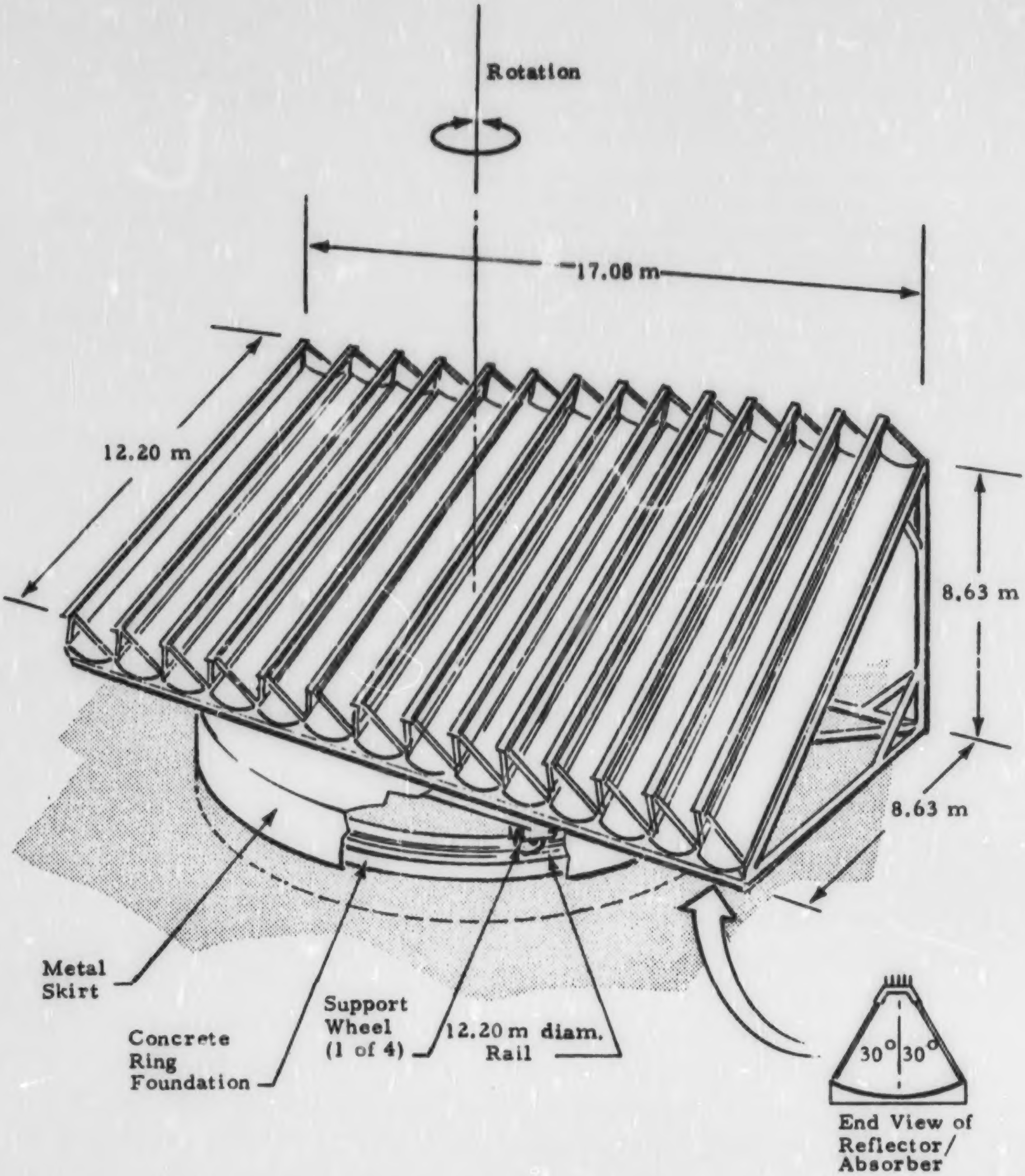

Rotation
17.08 m
12.20 m
8.63 m
8.63 m
Metal Skirt
Concrete Ring Foundation
Support Wheel (1 of 4)
12.20 m diam. Rail
30°
30°
End View of Reflector/ Absorber

Figure 1-3. 26 kW solar module concept.

Selective removal and replacement of troughs is possible, but adherence to configuration specifications (to retain desired optical characteristics) would be very difficult.

We conclude that long-term integrity of the reflective surface is one of the least proved elements of facility design. It ranks with battery storage in this respect. However, as discussed later, the facility can operate without storage, but not without reflectors. These considerations seem to argue persuasively for sequential plant construction, as described in Section 1.3. By bringing earliest units on-line as they are complete, performance histories may be compiled and used to upgrade design features on a dynamic basis during plant construction. Slipped schedules due to such actions would not affect the operation of units already functioning.

2. Degradation of plastic and adhesive has potential environmental consequences which demand future assessment. Atmospheric emissions and introduction of organic contaminants into run-off water are two aspects. Identification of emissions and discharges and transport modeling for this distributed source would have to precede an evaluation of occupational hygiene effects, public health effects, and ecological effects.

The absorber has a 6.1 cm x 12.20 m strip of silicon solar cells, contained within a Winston-type concentrator with 12.2 cm aperture area. A cross-section view of a typical segment is also shown in Figure 1-3. The absorber (with solar cells) is passively cooled using air convection and operates nominally at 100 C. The total nominal peak output of the 14 segments is 26 kW.

The module is constructed almost entirely of steel, including the primary concentrators. The structure sits on four wheels which ride a 12.2 m diameter circular rail supported by a concrete ring foundation. Horizontal restraint is accomplished using a center column foundation and bearing 208 m^2 located at the center of the base of the module. The over-turning tendency arising from high winds is resisted by a combination of the steel structure weight, and the center column foundation. Water run-off from the 208 m^2 inclined surface of the module is collected and channeled onto a gravel pad inside the circular area beneath the module. As shown later (cf., Fig. 2-4, the "100 year rain" in this area is about 6.4 cm, and this would occur over a 12-hour period. Therefore, it would be an extraordinary event were rain to fall fast enough to collect inside the ring and flood the track and then freeze and disable the tracking mechanism.

Ice and snow collecting on the primary troughs would temporarily reduce or eliminate collection. The arrangement prevents soil erosion around the module and places the water approximately where it normally would have fallen. As shown in Figure 1-3, the module has a circular metal skirt at its base to prevent build-up of airborne sand and dust near the support rail.

For sun-tracking, the module is equipped with a motorized mechanism to rotate it by driving one rear wheel.

Foundation and Module Erection: The center column foundation is 92 cm in diameter by 5.5 m below grade. The ring foundation is 46 cm wide and extends 61 cm below grade. Total concrete volume is 16 m^3 per module, requiring therefore, 0.80×10^6 m^3 of concrete for the 50,000 module installation.

The modules will be mass produced at suitable industrial facilities and shipped to the site by rail or truck for assembly and placement on the prepared foundations. Foundation construction will proceed as follows: when soil loosening and grading operations are completed, construction of the center column proceeds. An auger drills a 92 cm diameter hole to a depth of 5.5 m and a preformed reinforcing bar cage is lowered into place, followed by formwork and concrete placement. The ring foundation is made ready with a trenching operation, after which the concrete is placed and the rail is mounted. The concrete will be obtained either from portable on site batch plants or from ready-mix plants near the solar power plant site. Availability of cement does not appear to be a problem since there is a large Portland cement plant in the immediate vicinity, and numerous cement manufacturers are located elsewhere in the region.

Powerplant Wiring: The overall wiring network brings power from the solar modules to the plant site boundary and interconnects the major equipment items. The power wiring network consists of four major areas: dc buses, 34 kV distribution system, a switchyard and a 230 kV transmission line. Station power and grounding systems are also included.

The 34 kV, 60 Hz ac, three-phase distribution system includes all wiring and components required for connection of each power conditioning module power output terminal to the 34/230 kV switchyard input terminals on the two 34 kV line dead-end terminus structures.

The 230 kV transmission line system includes all wiring, components and towers required for connection from the 34/230 kV switchyard dead-end structure. Terminals and a 230 kV tower structure are located on the plant boundary line, where continuation is by the utility, using the existing transmission corridor and lines shown later in Figure 2-1. The switchyard is shown in Figure 1-4.

With the exception of the large amount of distributed wiring to interconnect the 50,000 solar modules, the power wing is conventional in amount and design. An environmental effect unique to a solar power plant is the large amount of relatively small diameter module interconnect wiring placed underground. This is not seen as a problem area.

Power Conditioning Modules: A typical power conditioning module (PCM) consists of a power regulator, storage battery, dc-ac inverter, and a controller. The PCM, of which there will be 500, is shown schematically in Figure 1-5. The regulator, in conjunction with the controller's microcomputer, tracks the solar module characteristics for variations in solar input and temperature to maximize power output from each solar module. The input power to each regulator will be 2500 V x 1800 A. The regulator equipment is in a portion of the inverter building and is located as shown in Figure 1-6. The regulator is air cooled using a portion of the inverter cooling system.

The lithium/sulfur batteries will be located in a 3.7 x 16.8 m battery building as shown in Figure 1-7. The building is all-steel construction, with a 15 cm thick reinforced concrete floor.

Battery development is due to Argonne National Laboratory (Ref. 1-3). The battery bank will be 2.4 x 12.2 x 3.1 m high with a nominal weight of 79 MT.

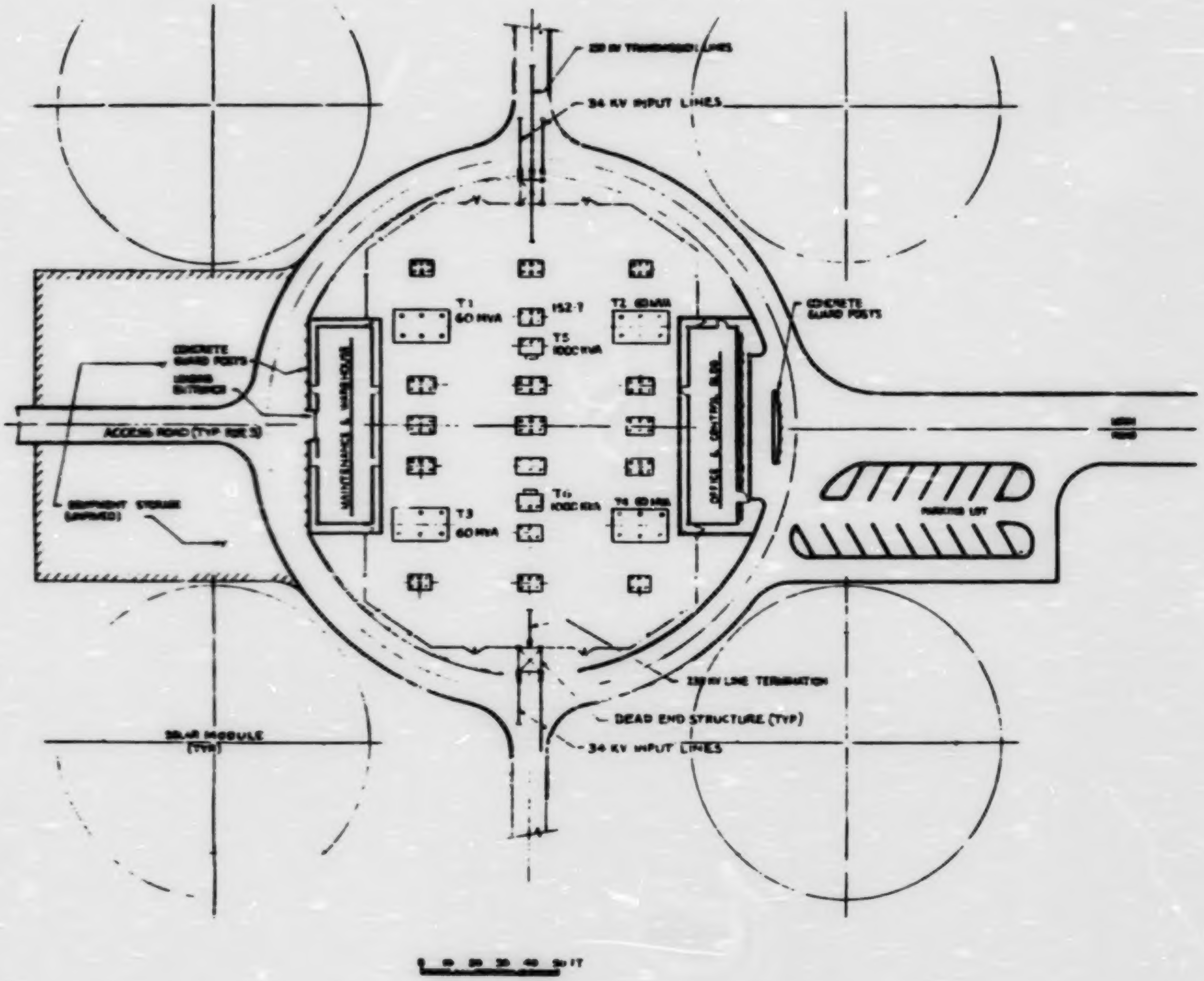

230 KV TRANSMISSION LINES
34 KV INPUT LINES
CONCRETE GUARD POSTS
LOADING ENTRANCE
ACCESS ROAD (TYP SEE 3)
EQUIPMENT STORAGE (UNPAVED)
MAINTENANCE & WAREHOUSE
T1 60 MVA
152-T
T5 1000 KVA
T2 60 MVA
T6 1000 KVA
T3 60 MVA
T4 60 MVA
OFFICE & CONTROL BLDG.
CONCRETE GUARD POSTS
PARKING LOT
MAIN ROAD
230 KV LINE TERMINATION
DEAD END STRUCTURE (TYP)
34 KV INPUT LINES
SOLAR MODULE (TYP)
0 10 20 30 40 50 FT

Figure 1-4. Switchyard and headquarters complex layout (Ref. 1-2).

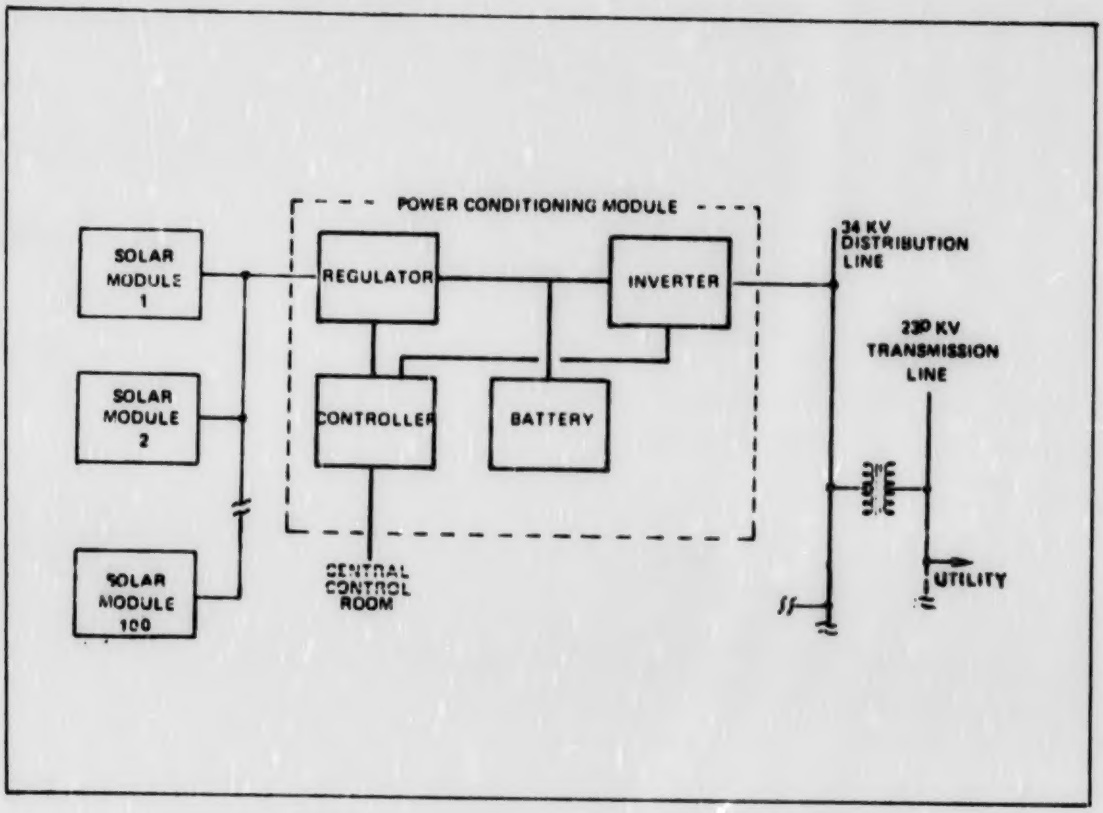

POWER CONDITIONING MODULE
SOLAR MODULE 1
SOLAR MODULE 2
SOLAR MODULE 100
REGULATOR
INVERTER
CONTROLLER
BATTERY
CENTRAL CONTROL ROOM
34 KV DISTRIBUTION LINE
230 KV TRANSMISSION LINE
UTILITY

Figure 1-5. Power conditioning module functional block diagram (Ref. 1-2).

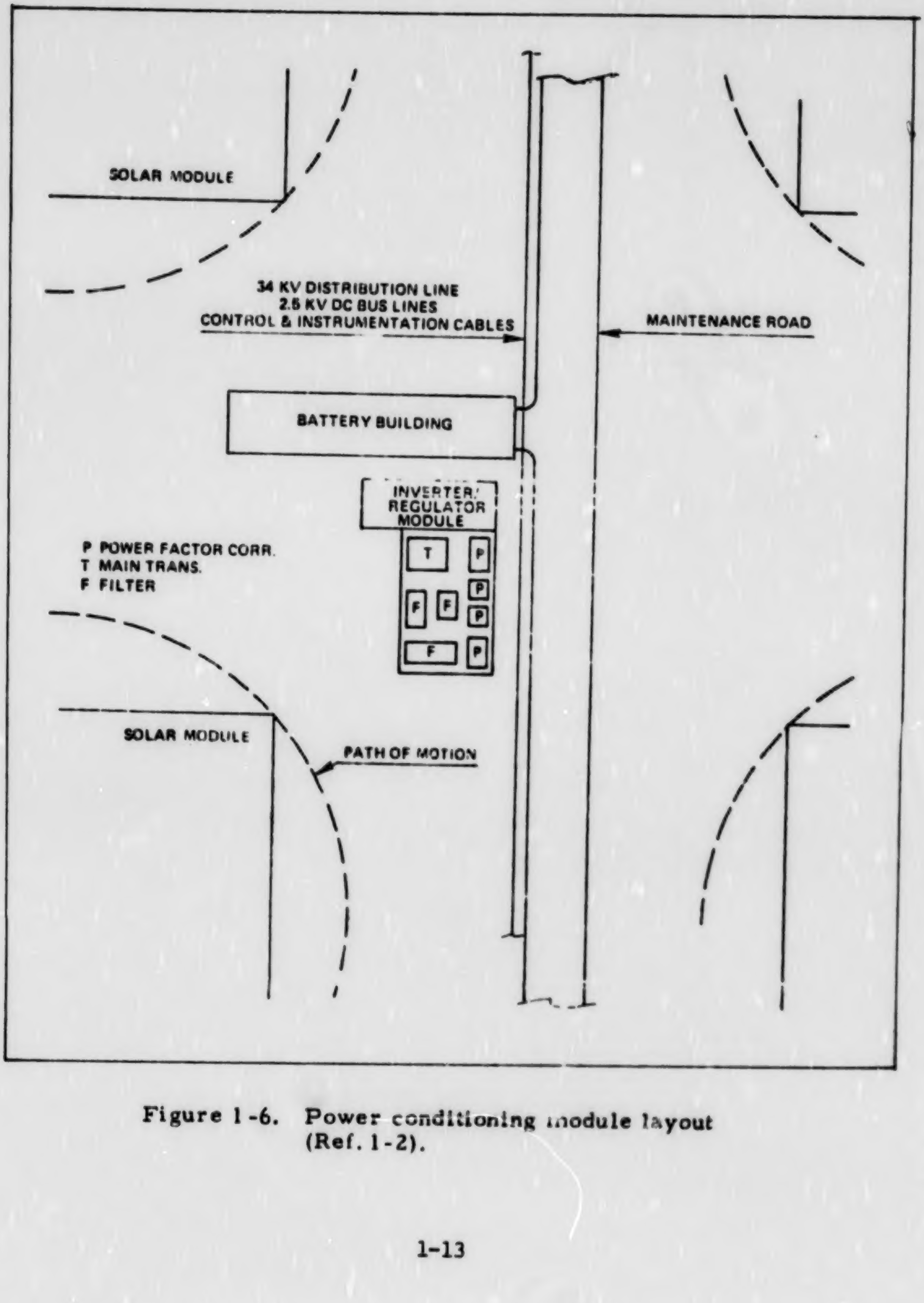

SOLAR MODULE
34 KV DISTRIBUTION LINE
2.5 KV DC BUS LINES
CONTROL & INSTRUMENTATION CABLES
MAINTENANCE ROAD
BATTERY BUILDING
INVERTER/ REGULATOR MODULE
P POWER FACTOR CORR.
T MAIN TRANS.
F FILTER
T
P
F
F
P
P
F
P
SOLAR MODULE
PATH OF MOTION

Figure 1-6. Power conditioning module layout (Ref. 1-2).

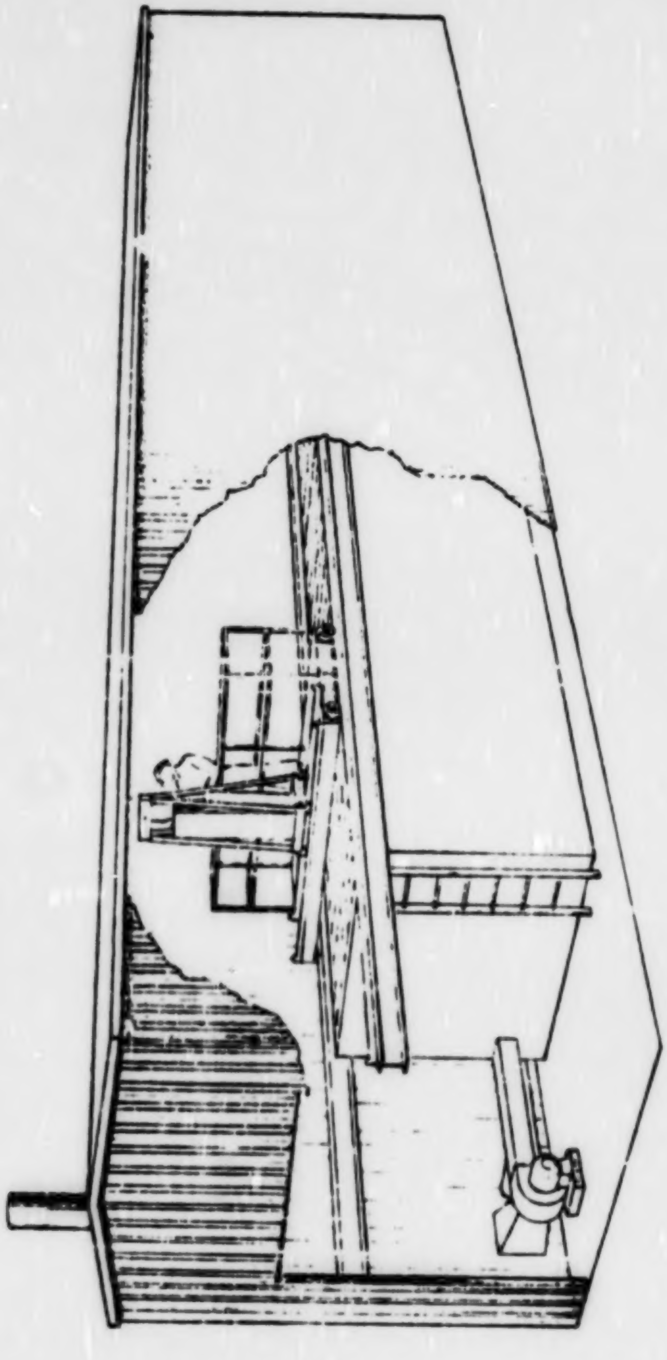


Figure 1-7. Battery building (Ref. 1-2).

The cells operate at 450 C. The batteries are insulated so that the exterior surface is 32 C.

Argonne projections suggest that the overall (in-out) battery efficiency will be 80%. Of the 20% energy loss in a charge-discharge cycle, 8% will occur during charge and 12% during discharge.

Auxiliary heaters are embedded in the battery banks for reheat in the event of an idle period exceeding two days. Normally, however, the reject self-heat will maintain the batteries within their operating temperature range and no additional power is to be supplied. Should auxiliary heat be required; however, the resistance heaters will expend about 1 kW/100 kW generating capacity. Waste heat is removed by circulating air which is discharged at 20 ft above grade. Of the total battery mass, 6% is Li (as metallic Li-$A\ell$ alloy and as Li-$C\ell$). About 1 to 2% is $A\ell$. The remainder is $KC\ell$, Fe, S, BN, and structural components. Boron nitride woven fabric is the costliest single component of a battery, at approximately $0.19\ m^2$ (20 to 40 g)/kWh and \$2150 to $\$3225/m^2$. There is some prospect that a nonwoven boron nitride felt can be developed for which cost projections are about $\$11/m^2$. A battery fire would release caustic Li_2O as well as SO_2, $A\ell_2O_3$, and various pyrolysis products of structural components. Non-aqueous fire suppression measures would be required. However, potential fire hazards due to the high temperature lithium alloy and other constituents are believed to be minimal since these materials are contained within an iron cell casing that is further contained in submodules and insulated containers.

Plant Operation and Operating Modes: A discussion will now be given of the basic operating modes of the integrated power plant and of the operational concepts for the solar modules, energy storage batteries, and support equipment. This discussion is relevant to the environmental analyses because it relates to the manner in which the plant operations impact utility grid performance and hence demand for intermediate peaking capacity, utilization of turbines, pumped hydro, and older (inefficient) coal fired plants.

To assist the reader, the following plant nomenclature is provided.

Collector:	A single parabolic trough primary supporting a single Winston secondary containing a string of photovoltaic cells. (Inset, Figure 1-3)
Solar Module:	A single sun-tracking, rotating structure, containing 14 collectors (Figure 1-3).
Group:	An electrically interconnected set of 100 modules (Figure 1-2).
Array:	The 52 km^2 assembly of 500 groups (50,000 modules)
Power Conditioning Module:	The pair of buildings comprising battery storage, regulator, and inverters, etc., servicing one group of 100 modules (Figures 1-5 and 1-6).
Unit:	One of the two geographically separated sections of the plant (Figure 2-1).

The following discussion is extracted from the Bechtel report (Ref. 1-2) with slight modification.

For the most part, existing plants in a utility system are operated on demand and at rated power. Base-loaded plants are kept operating on a nominal 24-hr-per-day basis. Since the mean number of hours of sunshine for Las Vegas is 10.5 hr per day (not at full intensity) and storing an additional 13.5 hr (or more) of energy would be too costly, operation as a base loaded plant is not practical. The time of day during which solar energy is available and the length of time it is available would make operation of the photovoltaic central station similar to that of an intermediate-type plant. However, classification into a particular category is much less important than incorporating the operation of solar power plants into existing and future generating mixes in a manner that results in the most economical operation of the entire utility system. With the present conceptual design, the photovoltaic central station power plant operates with power output undiminished by transient cloud cover for as many hours per day as available insolation and stored energy permit. The stored energy can be derived from solar energy, off-peak utility, or both.

Typically, daily load curves for a utility show demand to increase sharply between 8 and 10 a.m. Demand decreases between 6 and 8 p.m. and then levels off until a sharp decrease at between 10 and 11 p.m. Some utilities have a second, smaller peak in the late evening hours. Load demand curves for weekends have a similar general shape but at a lower power level. The level of power also varies seasonally. To contribute to the utility system's ability to meet such load demands as effectively as practical, it is projected that the photovoltaic central station be operated in a manner similar to that indicated by Figure 1-8.

In Figure 1-8, the solid line indicates power available from the solar array. The dashed line indicates the power being supplied to the utility grid by the plant. The differences between these two power levels (as indicated by the shaded areas in Figure 1-8), represent power used to charge the storage battery or power supplied to the inverter by the battery. The dotted line represents power supplied by the utility to charge the battery. The battery charge area indicated is larger than the discharge area due to energy losses in the battery. The curves shown are highly idealized and are not to scale; they are intended only to present a general overview of the intended operating scheme on a typical day. Operation during periods of transient cloud cover, although not specifically illustrated, will be shown for Mode 4 (see definition of all operating modes in a later paragraph).

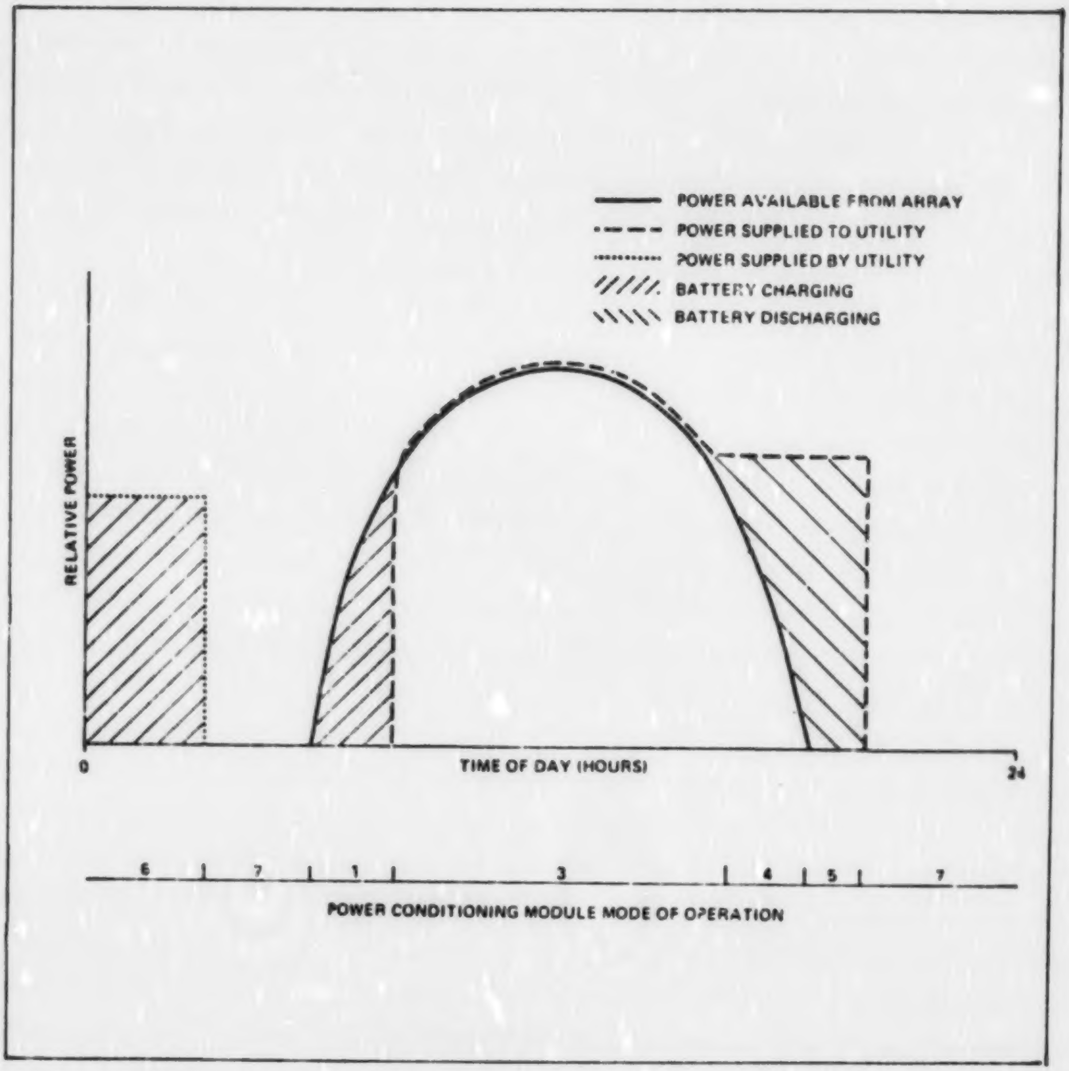


Figure 1-8. Plant and power conditioning module operation as a function of time of day (Ref. 1-2).

Briefly, operation on a typical day is as follows. Off-peak energy from the utility is used to partially charge the energy storage batteries during the night. Charging is completed with solar energy during the early morning hours. As charging is completed and the utility load increases, available solar power is supplied to the utility grid. Stored energy from the batteries is used to maintain plant output during periods of cloud cover and as insolation decreases in the late afternoon. Stored energy, as available, is also used to extend operation of the plant past sunset.

Of course, not all days are typical. On some days, cloud cover will result in an early draining of the batteries. Also, available solar power and load demand will vary seasonally. Operation of the plant will involve evaluation of weather forecasts, utility load forecasts and coordination of demand with expected amounts and times of availability of insolation.

Alternatively, should relatively inexpensive off-peak energy be unavailable, the plant would be operated as shown in Figure 1-9. In this case, on a typical day the plant is operated so that solar energy collected during the early morning is stored. At midmorning, the plant is connected to the utility and supplies power at a fixed level for the remainder of the plant's operating day. Available solar energy in excess of that supplied to the utility is stored. Stored energy is used to supply power to the utility during periods of cloud cover and, in the evening, as solar power decreases, to extend plant operation past sunset. Another alternative is zero energy storage which was discussed previously.

Many variations and combinations of the above general plant operating schemes are possible. A major advantage of the first scheme (i.e., Figure 1-8) is that maximum power might be supplied during the time of greatest load demand. A second benefit is that the fully discharged storage batteries are initially charged at a high rate, a process that enhances their performance. Thus, it is proposed as the primary operating scheme and forms the basis for this current preliminary conceptual design.

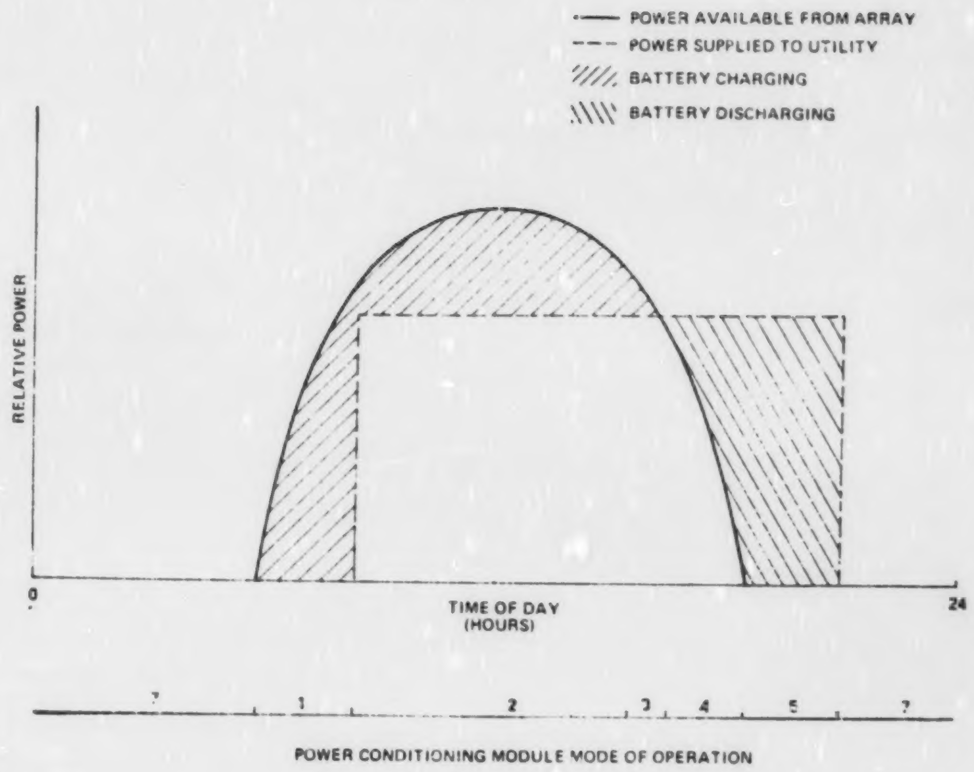


Figure 1-9. Alternate plant and power conditioning module operation as a function of time of day (Ref. 1-2).

Power Conditioning Module Operation: Operation of the plant as described is accomplished through the combined operation of the power conditioning modules. There are seven basic modes of operation for each of the 500 power conditioning modules:

1. Group (of 100 modules) supplies power to battery only
2. Group supplies power to battery and inverter simultaneously
3. Group supplies power to inverter only
4. Group and battery both supply power to inverter
5. Battery alone supplies power to inverter
6. Power supplied by the utility to charge battery
7. Shutdown.

The juxtaposition of these modes on a typical day was shown on Figures 1-8 and 1-9. The ensuing discussion of power conditioning modules is preliminary in nature, and the times of day given for initiating operations in the several modes and power levels are subject to revision. As data on the array output as a function of time of day become available in actual operation, a logical step would be to reevaluate the preliminary calculations and assumptions used to arrive at the operating scheme by modeling the system on a computer. The model should include factors such as statistical fluctuations in temperature, cloud cover, wind (as it relates to power increases resulting from improved array cooling) and atmospheric conditions in general. Based on available data, operation of the power conditioning modules on a typical day can be described as follows:

> Mode 1 – Group Supplies Power to Battery Only. In the early morning hours, between sunrise and 9 a.m.; energy available from insolation is stored in the battery. The available power varies from zero to about 20 kW per module at 9 a.m. when the utility begins to draw power. During summer, available solar energy may allow supplying power to the utility at 8 a.m. Winter conditions may require a shift to a 10 a.m. start. During these hours, as well as all sunlight hours, the modules revolve about a vertical axis to track the sun. Conversion of solar energy is further optimized by operating each power conditioning module to track the maximum power point of the combination of the 100 solar modules connected to its input. This is accomplished by adjusting the regulator to produce the output voltage that results in having the power supplied to the battery correspond to the maximum power available.

When the battery is fully charged, the program will alert the central station's control room operators and adjust the regulator to operate in one of the following modes as preset by the plant operators in the control room computer.

- Completely stop drawing power from the group (Mode 7)
- Draw available power from the group (up to the maximum capability of the inverter) and supply it to the utility (Mode 3).

Obviously the latter routine would maximum the use of the plant and thus obtain the maximum amount of energy per dollar of invested capital. Bringing power on line is coordinated with the utility system dispatcher.

Mode 2 – Group Supplies Power to Battery and Inverter Simultaneously. As in Mode 1, the controller adjusts the firing angle of the regulator to obtain the maximum power available from the groups and monitors the state of charge of the battery. A separate control system, which is part of the inverter electronics, maintains the ac output of the power conditioning modules at the set value. This is accomplished independently of the dc voltage at the regulator and battery terminals in the same manner that the inverter portions of commercially available uninterruptible power supplies (UPS) maintain a constant power output while tracking the voltage variation associated with a discharging lead-acid battery. If the set value of inverter power exceeds the available solar power, operation in Mode 4 commences.

Mode 2 operation is illustrated in Figure 1-10, which shows the voltage and currents at the junction of the regulator, battery and inverter terminals. As indicated in the figure, the maximum power available from the module combination, Pm, is a fixed value for this moment in time and can be delivered at any voltage through the variable ratio transformer action of the regulator. Similarly, the nominal set inverter power, P_i, is constant for this moment and can be extracted from the battery/regulator/invertor junction at any voltage. The power into the battery, P_b, is a voltage dependent variable. As mentioned, the difference between the maximum available power from the group and the inverter power is used to charge the battery:

$$P_m - P_i = P_b \quad \text{(a)}$$

Or, since only one voltage can exist at the junction between this equipment:

$$I_m - I_i = I_b \quad \text{(b)}$$

The inverter draws a fixed amount of power, P_i. The characteristics of the solar cells are such that if the battery draws more or less than the optimum power, P_b, the power from the group will decrease. In setting the regulator to draw the maximum power from the arrays, the controller adjusts the regulator output voltage to a single optimum value, V, such that Eq. (a) is satisfied. The value of this voltage, of

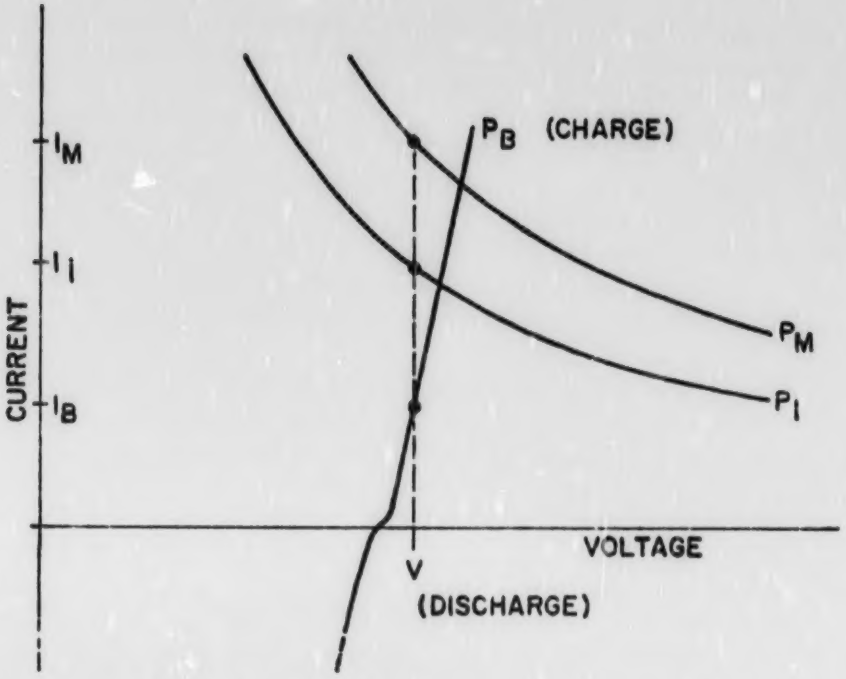


Figure 1-10. Regulator operational characteristics – $P_m > P_i$ (Ref. 1-2).

course, depends on the stage of charge of the battery. The foregoing description is somewhat simplified and is intended only to convey the basic principles of operation. Similarly, Figure 1-10 is not to scale, and the current-voltage characteristics of the energy storage battery have been simplified to straight lines. Actual battery characteristics are a continuum of curves encompassing all states of charge. A more detailed analysis would also take into account regulator efficiency, transient response times and control system stability, but such an analysis is beyond the scope of the present conceptual design effort.

As with Mode 1, when the battery approaches full charge, the power conditioning module controller will alert the control room operators and adjust the regulator to operate as follows in one of the two subroutines of Mode 3:

- Draw only sufficient power from the group to meet the power set for the module output.

- Change the set value of power output from the power conditioning modules and supply the maximum available amount of solar power to the utility grid.

Mode 3 – Group Supplies Power to Inverter Only. A power conditioning module operates in this mode when its energy storage battery is fully charged. Operation in this mode is similar to that of Mode 2, but the power to the battery P_b, is equal to zero, and the inverter power is equal to the group power (i.e., $P_i = P_m$).

Referring to Figure 1-11, the curves for P_i and P_m coincide, and the optimum operating voltage, V, is set so that the battery neither supplies nor draws current.

Actually, the controller adjusts the regulator and inverter to operate in either one or two subroutines in Mode 3 (as described above):

- The regulator and inverter track the group characteristics to deliver the maximum available solar power to the utility grid up to the maximum rating of the inverter.
- The regulator is adjusted to deliver only the amount of power preset for each module; the maximum power point of the group combination is no longer tracked and operation in this subroutine is less desirable.

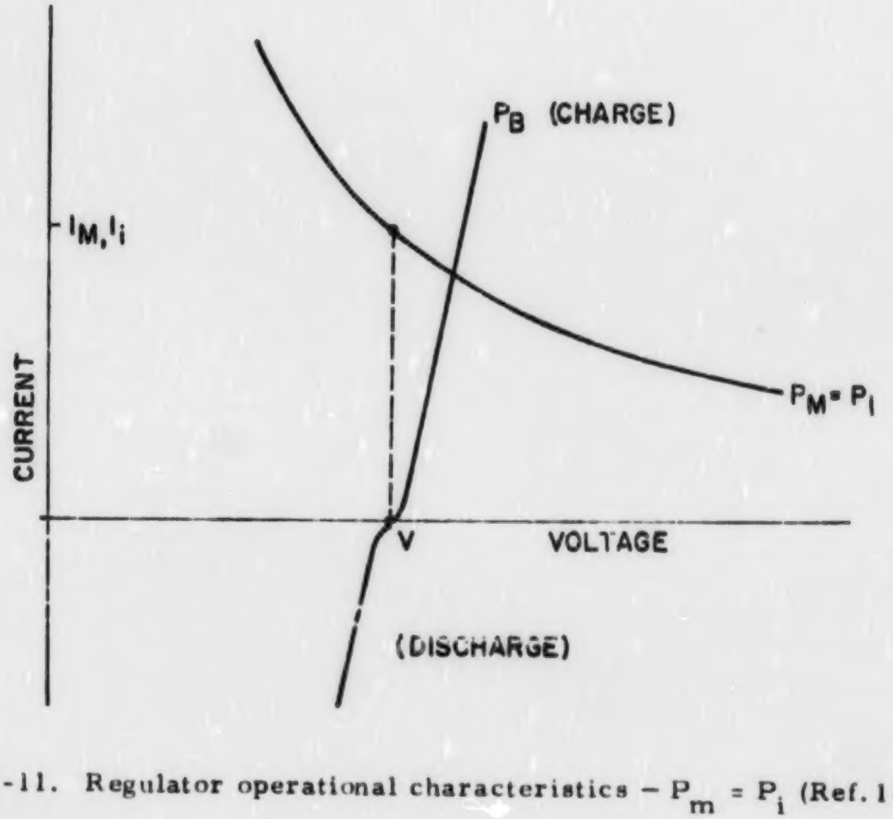


Figure 1-11. Regulator operational characteristics – $P_m = P_i$ (Ref. 1-2).

Mode 4 – Group and Battery Both Supply Power to Inverter. During times when the maximum power available from the group P_m, is less than required to meet the power set to be delivered to the utility by the by the inverter, P_i, the stored energy in the battery is used to supply the difference and maintain the power conditioning module output at its set value. As illustrated in Figures 1-8 and 1-9, this occurs in the late afternoon, during hours of waning insolation. Operation in this mode also occurs during periods of transient cloud cover (not illustrated).

Figure 1-12 illustrates the operation in this mode. In this mode, $P_m < P_i$, and operation at the maximum group power point requires that:

$$P_b = P_i - P_m$$

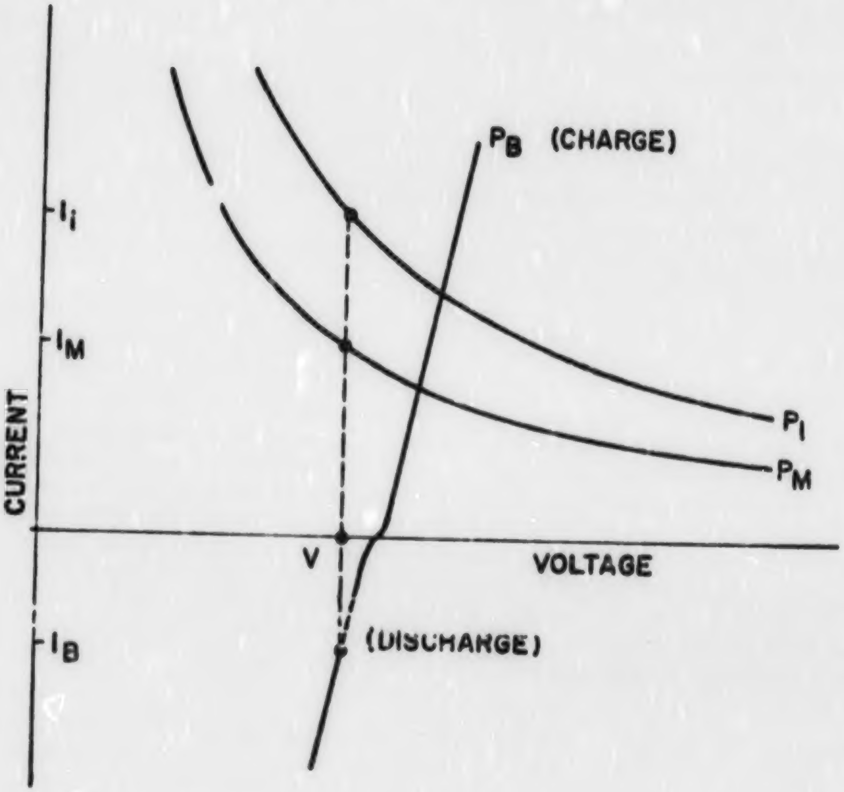


Figure 1-12. Regulator operational characteristics – $P_m < P_i$ (Ref. 1-2).

As with other modes, control electronics within the inverter maintain power output at the set value, P_i, independently from the dc input voltage. The controller adjusts the regulator to draw the maximum available power from the groups, P_m, and, through the variable ratio transformer behavior, delivers P_m at the optimum voltage, V. At this voltage, the discharging battery supplies a current, I_b, such that $I_b = I_i - I_m$ and Equation (a) is satisfied.

If during operation in Mode 4, the battery becomes discharged to a point where it, in conjunction with the solar modules, can no longer supply the rated power to the inverter, the plant control room operator is alerted and one of two modes is initiated:

- The module is shut down (Mode 7).
- The group alone supplies a lower level of power to the utility (Mode 3).

Mode 5 – Battery Alone Supplies Inverter. This mode is an extension of Mode 4, with the group power equal to zero ($P_m = 0$). Energy stored in the battery supplies power to the inverter and permits operation of the plant when severe cloud cover reduces the practical output of the solar group to zero or past sunset, when stored energy is available.

In this mode, $P_b = P_i$, and the operating voltage is set by the inverter at whatever level is required to draw the set value of power from the battery. This is analogous to the operation of an uninterruptible power supply. When the energy stored in the battery is depleted, as indicated by a preset cutoff voltage, the power conditioning module is shutdown (Mode 7).

Mode 6 – Power Supplied by Utility to Charge Battery. The prime function of the battery is to store energy and deliver this energy when transient cloud cover would otherwise reduce the plant output. The battery also enables plant operation to be extended past sunset. Since the power conditioning modules and battery can function as an energy storage load leveling facility, the plant should be operated in this manner when circumstances dictate i order to derive maximum benefit from invested capital. In particular, when weather forecasts indicate that insolation on the following day will be greatly reduced, the battery would be charged with off-peak energy from the utility grid during the night (midnight to 6 a.m.). To charge the battery, the inverter is operated as a phase-controlled rectifier. Stored energy (and available solar energy) is delivered to the grid on the following day in Mode 5 (or 4).

Mode 7 – Shutdown. In this mode, the regulator and inverter are turned off, and there is no power flow into or out of the power conditioning modules. A small amout of power is required to keep the controller electronics ready to act and to maintain the battery at temperature.

Operaton of Solar Modules: With the exception of the rotational tracking motion, the modules operate in a static fashion, responding instantly to change in any incident solar radiation and requiring no active cooling. In the evening each module is positioned automatically to face the easterly rising sun on the following morning. As the sun's azimuth angle increases during the day, each module rotates on its support track at the same rate of change as the sun's azimuthal rate. All control functions for the modules originate from a central computer located in the plant control building. Expected maintenance for the modules will consist of absorber assembly change-out, alignment checks, and tracking system servicing and adjustment.

Battery Operation: As with the solar modules, the operation of the lithium energy storage batteries is essentially a static process with the exception of cooling flows. When the batteries are cold prior to plant start-up the electrolyte is a solid and electrically inert. During the 3.5 day start-up period, the batteries (for each solar group) are heated with 20 kW of electrical power, normally obtained from solar energy. During operation, the cells are maintained at 450 C with the exterior (insulated) at 32 C. Air is recirculated at 375 C with outside air mixed to maintain operating temperature. During the standby period at night the batteries cool slowly but do not require heater power to maintain cell temperature within the operating range.

The batteries are expected to require replacement at approximately 5 to 6 year intervals. Aside from routine replacement and occasional replacement of a failed cell, the battery systems are expected to be essentially maintenance-free. Minor maintenance of the air cooling system fans and filters will be required.

The only conceivable environmental impact that the lithium-sulfur batteries could have is associated with a fire during which fumes could be released to the atmosphere. As indicated earlier, the lithium material is well enclosed and insulated and fire hazard is believed to be minimal. During installation or removal of the cells and submodules there will be no possible spillage since the electrolyte is solid at ambient temperature. However, since this type of battery has very little service experience, further investigation of the associated fire potential and environmental effects should be made.

Maintenance Facility and Philosophy

Receiving, maintenance and warehousing will occur in a steel building located on a concrete pad in the headquarters complex. A 4.8 km rail spur will be built from the Union Pacific line that runs basically parallel to U.S. Interstate 15. It will feed into the central warehouse and will be used during construction primarily, but will also facilitate shipping of replacement and removed modules, batteries, etc.

Trucks needed for periodic field maintenance and perimeter inspection will be light duty pickups and/or four-wheel drive vehicles equipped with high flotation off-road tires. These vehicles will be garaged at the maintenance facility. Mobile cranes and flat bed trucks capable of transporting entire modules are available in the Las Vegas urban area.

Lockheed-Huntsville has considered carefully the various alternative maintenance and inspection modes and "scenarios." A realistic estimate of the time required is based on the following: a two-man crew must load a truck, drive to a module possibly 8 mi distance, disembark, walk around a module, inspect module wheel bearings visually, shovel a minimum of blown sand from the track, and continue in like fashion to successive modules. Periodically the crew would pause to move the truck, record observations, communicate with a shift foreman, and attend personal needs.

It seems quite unlikely that such a crew could inspect more than 25 modules in an 8-hr shift. Thus, at least 2000 shifts or almost 16 man-years would be required for each of 50,000 modules to receive one inspection by a two-man crew, and practically no maintenance.

It is concluded, therefore, that all maintenance must be by "management by exception." Consequently, we anticipate that each module will be equipped with extensive remotely monitored troubleshooting and performance test equipment. This would include at least a simple electrical output monitor, torque or current demand surveillance sensors for drive motors, temperature sensors on motors and perhaps absorbers, etc. Wheel bearings would necessarily include provision for unattended continuous lubrication with seals to prevent admission of abrasive dust.

The output of each absorber may have to be monitored, at least on a trial basis in earlier groups. This would assist design upgrading teams in determining the effect of dust burden and small animal intrusions on reflector performance.

As an additional device to minimize field maintenance, several complete modules will be stored at the maintenance shops or at distributed field sheds. These would be kept as nearly ready-to-go as economically feasible. When non-trivial maintenance operations become necessary, an entire module would be removed and replaced. The defective unit would then be transported to the shops, where its repair could be scheduled locally or at a factory. A similar approach will be applied to scheduled and unscheduled battery replacement.

This maintenance management philosophy appears to be consistent with the small (50 man) operating crew envisioned. By stepwise construction, bringing each 2 MW group on line as it is completed, operating and maintenance experience can be reflected in occasional design improvements during construction. Consult the previous discussion of reflective surface deterioration.

This is a very small work force for a 1000 MW generating station. However, the station is unique in not requiring several distinct types of personnel. These personnel, include, for example:

- Coal delivery and receiving personnel, including drivers, equipment operators, scales operators, and associated foremen
- Applied health physics personnel (in the case of nuclear plants)
- Fuel test lab personnel
- Ash handling personnel
- Pond management personnel

- Cooling tower maintenance crews
- Environmental monitoring technicians (river sampling and analysis, stack gas samples, etc.)
- Baghouse and precipitator maintenance crews
- Clerical and supervisory personnel related to regulatory agencies: compliance inspections and reporting, forms management, etc.

Central Headquarters Facility

The headquarters building will house the management office and central control systems, security, etc. The central control room includes all panelboards, displays, instrumentation and control elements necessary for data acquisition, remote monitoring, supervision and control of the plant. The modular control room panel is provided with a backlighted mimic display of the power plant power flow from the 500 power conditioning modules through the plant for power delivery to the utility at 230 kV. The operative condition of the system is indicated by conventional signal lights that indicate normal or abnormal conditions.

Routine operation of the plant is by execution of programming stored in the central control room computer, with operator override to allow for coordination of available (or anticipated) insolation and of stored energy with utility system load demands. Changes to the program for plant operation or utility demands are entered by the operator at the operator's console. The computer in conjunction with the power conditioning module controllers sets the modes of operation for the plant. Also, control signals required for positioning (tracking and return) of the solar arrays are generated by the computer.

Communications Facilities

Communication systems necessary for plant operation and maintenance are located in the central control room building. These systems include:

- 230 kV power line carrier interface link to the utility system
- VHF transmitter and receiver for plant field mobile units
- UHF transmitter and receiver for utility system tie backup
- Local telephone system line
- Meteorological data receiver
- TV cameras and displays.

A 120 m communication tower is provided in a location (not yet determined) where it will cause no shadowing of any module. All transmitter/receiver antennas are mounted on this tower. Aircraft warning light systems are provided if required by FAA regulations.

Maintenance of plant security is facilitated by the remote controlled TV cameras mounted at selected perimeter and in-plant locations yet to be determined.

Transmission Lines

No new transmission lines are required. The 230 kV tower structure at the plant boundary will connect directly to the existing transmission lines in the corridor shown in Figure 2-1.

Visitor Center and Visitor Control

This enormous facility — to be the first of its kind and, for a while, the largest in the United States — is located in the vicinity of Las Vegas, Hoover Dam, and several national monuments and recreation areas. The facility is expected to be, for a time, a major tourist attraction.

To facilitate visitor control and to minimize traffic problems associated with visitor access, a visitor's center will be established outside the plant perimeter and adjacent to an interchange on Interstate Highway 15.

Educational displays will include subscale workups, movies, motorized models, and visitor-interactive exhibits. Bus tours into the plant headquarters area can be provided should a demand develop.

The visitor center and associated service offices will occupy most of a 744 m^2, one-story stone structure of indigenous architecture. Building services will include restrooms and snack services initially for 100 visitors per day. A parking lot for 50 vehicles and a bus discharge lane are envisioned. Provision for expanding the facilities is assumed but not detailed.

Water Supply and Sewerage

This photovoltaic generating plant requires no process water or cooling water. Potable water and water for sewage treatment and maintenance are required. There is to be no provision for washing reflective collector surfaces. Consequently, the plant will not require an extensive system of water supply lines.

During construction, crews will be supplied by water truck with 8 m^3 potable water/day, and sanitation requirements will be met with portable chemical privies. Substantial amounts of water are needed for production of 0.765×10^6 m^3 of concrete used in foundation preparation. No water pipeline is planned. Concrete suppliers will operate portable batch plants with trucked water, or will deliver premixed concrete to the construction site.

Possibly as much as 2850 m^3/day will be needed on-site if a batch plant is located there. A source of construction water has not been identified.

Ground water is of low quality, possibly in part because other installations in the vicinity use deep wells for process waste and sewage injection. Hence, all potable water will need to be transported to the site even during normal operation. For this purpose, the headquarters complex and the visitors' center will each require 12 m^3 potable water per day, purified on site by a small package plant.

During operation, both headquarters complex and the visitors' center will be served by package sewage plants, with capacities of 12 m^3/day.

Vehicles will not be washed on site. If a need for significant quantities of water for maintenance should develop, non-potable well water is a possible solution, but a small pipeline run in along the access road is a more attractive alternative.

Transportation Facilities

Roads: A permanent access road from Interstate Highway 15 will be constructed of asphalt at beginning of construction and utilized as the main access road during construction and operation. This road will be approximately four miles long and will have an interchange on I-15.

Design, approvals, funding, etc., will require a substantial period of time before construction can commence. This should be initiated immediately upon project go-ahead.

The visitor center, outside the plant perimeter, will have an asphalt parking lot for 50 vehicles and a bus discharge lane occupying several acres. Provision for expansion is necessary.

The road leading to the headquarters and maintenance complex will be a permanent asphalt three-lane access, designed for heavy equipment traffic.

The headquarters parking lot is to accommodate 50 vehicles, and will also include a bus discharge lane.

Throughout the plant, 6.7 m wide improved (asphalt) maintenance roads will be spaced every 329.4 m with north-south orientation. No asphalt east-west roads are planned. However, vehicular access on 15 cm thick crushed rock spur roadbed will be provided for each module. Hygroscopic dust suppressant treatment may be necessary periodically.

All light duty vehicles assigned to maintenance will require "high-flotation" off-road tires.

Railroad: A rail spur line with local side tracks at the warehouse will be constructed from the Union Pacific line that runs approximately parallel to I-15. The spur line will be approximately 5 km long with approximately 90 m of side tracks for railcar positioning.

Helipads: Occasional visitation by dignitaries requiring helitransport is anticipated. In addition, we expect to use helicopters on a trial basis for construction supervision, and for maintenance and inspection visits to remote areas of the plant. Therefore, helipads will be located near the visitor center, on the headquarters parking area, and at several remote locations within the plant area.

Plant Security

It is believed that this kind of generating station will be much less vulnerable to deliberate acts of massive sabotage or vandalism than a conventional non-modular fossil or nuclear plant. Further, it is expected that the installation will be accepted with much less public controversy. Therefore, security arrangement is aimed primarily at prevention of casual ingress, and theft prevention, public protection, and exclusion of large animals.

The entire plant area is to be secured with a 3 m chain link fence. Actual ingress at the plant's main entrance will be controlled from a guard shack. Unsupervised remote gates will be padlocked.

1.3 PROJECT SCHEDULE

Construction would begin in the western extreme of Unit 1, below Dry Lake, immediately following preparation of the initial (temporary) haul road from route U.S. 93. Essentially simultaneously, work would begin on preparing the interchange at I-15, and on construction of a railroad spur from the Union Pacific line. The spur would connect with the main line at a point in Section 21, R.64E., T.17S near the settlement of Dry Lake where the main line lies west of I-15. Thus no new overpasses over U.S. 93 or I-15 would be required. The cloverleaf interchange on I-15 and the temporary haul road from U S 93 would be the only interference with these two highways.

Early stages of construction activity are expected to employ 200 workers rather quickly, exclusive of employment in railroad and haul road construction. As land preparation is succeeded by foundation work and module installation, the work force will reach about 1000, and will continue near that level for several years. Meanwhile, land preparation crews move on to the next projected area. Construction is scheduled to be complete in ten years.

An advantage of the split site (units one and two being on opposite sides of Dry Lake) is that Unit 1 can be completed and be on-line, almost wholly undisturbed by continuing construction in Unit 2. A detailed logistical analysis has not been done to determine if the overall construction time would be shortened appreciably by opting for an integrated plant located in its entirety north of Dry Lake.

1.4 PROJECT COST

The total projected capital cost of this hypothetical 1000 MW solar energy plant has been estimated based on the current design, year 1990 solar cell cost projections, and other cost data from Refs. 1-1 and 1-2. The total capital cost of the plant is projected to be $1670 million, or $1670 per kilowatt (peak) (Table 1-1), exclusive of land costs.

Two major uncertainties in this estimate are:

1. A major cost element with a large uncertainty is the solar photovoltaic cells. Estimates of present day costs are $20 to $40 per watt. Table 1-1 assumes a projected cost of $1.00 per peak watt.
2. A breakdown of major plant cost elements appear in Table 1-1. Note that the cost of the solar modules, less the absorber units is the major cost item and one for which the cost will probably be reduced through mass production techniques. In particular, superstructures produced by techniques used in automotive and airframe industries are possible alternatives to the current design. The latter presumes welded construction using current industry standard tubing and pipe, for example.

TABLE 1-1. PLANT COST ELEMENTS

Item	$M
Solar modules, including foundations and construction cost	800
Solar cell absorber units[*] (14 per module)	200
Power wiring and controls	40
Power conditioning modules (including projected cost of batteries)	350
Labor at site[**]	20
Contingency at 15%	220
Total	$1670

[*] Based on $1.00 per peak watt for silicon colar cells, $10.00 per sq ft for reflector optics and structure.

[**] Labor other than for solar module construction.

Considering the possibility of reductions in the cost of superstructures, solar cells, and absorber optical components, it may be possible to reduce the plant cost to the vicinity of $1400 per peak kilowatt (1976 dollars). This exceeds the projected cost of the proposed $3GW_e$ Kaiparowits coal fired plant, $1167 per peak kilowatt electric, when that project was cancelled in April 1976 (Ref. 1-4

Because of diurnal variations in insolation, temperature cycling, etc., the ratio of peak output to average output will be approximately 5:1. Therefore, the theoretical maximum annual energy supplied by the plant (capacity factor 1.0) would be 1.75×10^6 MWh. This assumes unlimited storage. The 3 hours storage capability supplied for the plant limits the capacity factor to 0.50 in conventional terms. Actual capacity factors which might be experienced are unknown. Anticipated improvements in silicon absorber efficiency by the time final modules are installed will be offset to an unknown degree by degraded performance of older modules. Therefore, we take as an approximation a capacity factor of 0.5. This corresponds to an annual production of 0.876×10^6 MWh.

We use an 18% figure for annualized amortization, money cost, taxes and insurance, and 1.8% annual operating expenses. This is rather low, but possibly consistent with the small work force. The corresponding cost of delivered electricity is $0.377 per kilowatt-hour based on a level rate structure. This, of course, ignores land acquisition costs if any, and very possibly other hidden costs.

By way of comparison, retail residential power in the U.S. "sunbelt" from Tampa to Los Angeles and as far north as Salt Lake City ran $0.022 to $0.044 per kwh in the winter of 1975-76. One southeastern utility company paid $0.10 per kilowatt-hour during that winter for wholesale peak power off the grid. Even including a projected twenty-fold reduction in solar cell costs, cost of photovoltaic power from this station would exceed traditional power costs throughout the U.S. by a factor of 4 to 17. Because the incremental effect of a single plant on a large utility's overall delivered power costs would be small, stations similar in characteristics, cost and environmental effects may be built. Should other advanced energy options fail to assume importance (cf. Section V), or if fossil fuel costs inflate much faster than is happening now, demonstration plants of this type may become attractive because their capital costs are predictable and their labor costs small.

Many public utilities in the U.S. Southwest currently have very high fractions of natural gas in their fuel mix. These utilities necessarily will be seeking alternative energy sources as natural gas supplies become exhausted in the foreseeable future. We have not performed an analysis to determine if this generating station (hypothetically) would be going on-line with a timing permitting its substitution for gas-fired boilers. Such an analysis would have to relate the presumed timing of utilities' growing confidence in the viability of solar photovoltaic generation with the time of utilities' decision-making in the long lead-time preceding nuclear or fossil fuel plant construction. Such an analysis could be valuable to Federal and State energy and environmental administrators, but is outside the scope of the present task.

1.5 PERMITS AND REGULATIONS

Permits

No navigable waterways are used, crossed, discharged into, or withdrawn from. Consequently no U.S. Army Corps of Engineers nor U.S. Coast Guard jurisdiction exists. The installation has no tall stacks; no Federal Aviation Administration permit is required. The absence of liquid discharges means no USEPA-NPDES wastewater discharge permit is required. The Federal Energy Administration does not issue permits. It has authority to issue prohibition orders; we do not expect that to occur. The Nuclear Regulatory Commission is without jurisdiction. The number of areas in which regulatory jurisdiction is avoided is a unique characteristic of a power plant of this type.

The following permits are required:

Nevada – Certificate of Public Convenience and Necessity

Nevada – Authority to operate two package secondary sewage treatment plants

Nevada – Permit to construct, operate, and maintain overhead transmission lines

Nevada – Permit to drill well (if needed)

Clark County District Health Department – Permits relative to air pollution regulations.

In addition, there are potentially numbers of local permits and certificates relative to building codes, zoning, water supply, personnel certifications, business licenses, taxes, etc., which are beyond the scope of this task to discuss.

Clark County Regulations

Ambient Air Quality and Pollutant Emissions: Clark County, Nevada, air pollution regulations are contained in the District Board of Health of Clark County, Nevada, Air Pollution Control Regulations of January 28, 1973, and proposed amendments, dated March 27, 1974. The Nevada

Revised Statutes transfer authority to enforce and regulate state regulations from the State Environmental Protection Commission to the Clark County District Board of Health, Air Pollution Control Board. The Clark County Air Pollution Control Board is also authorized to adopt, amend, or modify rules and regulations, providing the action is consistent with, or provides more stringent control than, state regulations.

Some Federal, Nevada State, and Clark County ambient air quality standards and pollutant emission limitations are shown in Table 1-2. Clark County standards and limitations are equal to or more stringent than state and Federal criteria with the exception of oxides of nitrogen emissions where only Federal standards presently exist for steam generating plants. Clark County particulate matter regulations concerning opacity are more stringent than the Federal regulations restricting particulate emissions.

The proposed complex source regulation amendment to the air pollution regulations probably will not apply to this installation.

Registration and Permits (Air Quality and Fugitive Dust) for Source Emissions: Any person who causes, lets, permits, suffers, or allows the emission of air contaminants, whether or not limits are established, shall file with the Control Officer on forms provided by the Control Officer.

The applicant is required to provide information on refuse disposal, fuel used, and specific nature and quantity of the air contaminants emitted together with location of source and stack data. A separate application is required for each new source. The definition of a source of air contaminant is anything that emits any air contaminant. The Registration Certificate issued by the Control Officer is not an acceptance or approval of any article, machine, equipment, process or other contrivance listed on the Registration Certificate. The Registration Certificate is renewable annually on or before February 24 of each year.

TABLE 1-2. SELECTED AIR QUALITY STANDARDS

Air Pollutant	Federal Standards			Nevada State Standards		Clark County Standards	
	Averaging Time	Primary Standards $\mu g/m^3$	Secondary Standards $\mu g/m^3$	Averaging Time	Limits $\mu g/m^3$	Averaging Time	Limits $\mu g/m^3$
Particulate matter	AGM[*]	75	60	AGM	60	AGM	60
	24 h (not to exceed once/yr)	260	150	24 h (maximum)	150	24 h (maximum)	150
Ozone	1 h (not to exceed once/yr)	160[**]	160[**]	1 h (maximum)	160[**]	1 h (maximum)	160[**]

[*] Annual geometric mean

[**] 0.08 ppm.

No person is allowed to operate any item requiring a Registration Certificate unless an operating permit for such operation has been issued by the Control Officer and such permit is current and valid. The Control Officer may issue an Operating Permit on a conditional basis for a new source that requires some reasonable time for initial testing. Operating Permits are subject to revocation.

An Emergency Episode Plan will be prepared and submitted to the Control Officer defining a standby plan for reducing or eliminating emissions of air pollutants during periods of an air pollution alert, air pollution warning, or air pollution emergency as defined in Section 6 of the State of Nevada Air Quality Implementation Plan, which is entitled, "Emergency Episode Plan." In general, construction contractors for this project will be capable of appropriate operational cutback during emergency episodes. The episodes shall be identified when any of the specified pollutants exceeds the levels shown in Table 1-3 and meteorological conditions are such that pollution concentration can be expected to remain at levels above those shown in the table for 12 hours or more.

Fugitive Dust: The Clark County air pollution regulations require that no person shall cause or permit the handling or transporting or storage of any material in a manner that allows or may allow controllable particulate matter to become airborne. A further requirement states all activities associated with construction and operation of this plan will require all reasonable precautions to abate nuisance caused by dust and to prevent its (dust) transmission beyond the boundary line of the real property on which it originates.

The fugitive dust section of the Clark County Air Quality Regulations requires a current and valid permit issued by the Control Officer before any lessee, owner, occupant, operator, user, or any other person may disturb the topsoil of any property within Clark County, Nevada. The permit is subject to the applicant s agreements: to implement an acceptable

TABLE 1-3. POLLUTION CONCENTRATION CONDITIONS*

Pollutant/Meteorological Condition	Alert(a)	Warning	Emergency
Particulate, 24-hr avg. ($\mu g/m^3$)	375	625	875
Particulate coefficient of haze (COH)	3	5	7
Particulate x SO_2, 24-hr avg. (COH x $\mu g/m^3$)	524	2,096	3,144
($\mu g/m^3$ x $\mu g/m^3$)	65×10^3	261×10^3	393×10^3
Ozone, 1-hr avg. ($\mu g/m^3$)	200	800	1,200

*Excludes entries not relevant to proposed action.

method to prevent particulate matter from becoming airborne; to implement an acceptable method of securing the topsoil when the project is finished; to take additional precautions as may be reasonably prescribed by the Control Officer (consistent with the regulations); and to suspend all or part of his activities if he cannot provide satisfactory control of airborne particles, or upon notification by the Control Officer or his representative.

Nevada Air Quality regulations require a fugitive dust registration certificate or operating permit for the purpose of clearing, excavating, or leveling land of 8.1 hectares or more for any building construction. An operating permit for the deposit of any foreign material covering land of 8.1 hectares acres or more is also required.

In accordance with the Nevada Revised Statutes, the State of Nevada has authorized the Clark County Air Pollution Control Board to regulate and enforce State and County Air Quality and Fugitive Dust regulations. Furthermore, the Control Officer (Clark County) is required to make available to the applicant the necessary procedures and application forms.

Noise: Property development standards of Clark County Nevada Zoning Code contain noise restrictions. Clark County, Nevada, Code 29.44.50, Subsection K, specifies the octave band levels of noise which shall not be exceeded at each boundary line of the property on which sound is generated. The exceptions to the noise code allow temporary noise that is due to construction activities. The proposed activity will be in complete compliance.

Land Use: The Clark County Regional Planning Council is a coordinating group between the Clark County Department of Planning, State Department of Conservation and Natural Resources, and Federal agencies such as the Bureau of Land Management. The Council published a Clark County Park and Open Space Plan in 1971 with recent updates indicating resource inventory and potential areas of similar development, including priority recommendations.

State of Nevada

Air Quality: State of Nevada air pollution regulations are contained in the State of Nevada Air Quality Regulations, Sections 1 through 12, as amended February 24,1974, effective March 27, 1974. Enforcement authority is contained in the Nevada Revised Statutes. Nevada has also prepared and submitted its Air Quality Implementation Plan to the Environmental Protection Agency, accompanied by a letter from the State Attorney General's office stating that the required legal authority exists for the State of Nevada as promulgated in the Federal Register, dated August 1971, to execute its implementation plan for Federal air quality standards in conformity with Clean Air Amendments Act of 1970. The State of Nevada ambient air quality standards were shown in Table 1-2.

Fugitive Dust: State of Nevada Fugitive Dust regulations are contained in the Nevada Air Quality Regulations. The Clark County and State of Nevada requirements are essentially identical with minor differences in which Clark County is more stringent and specific.

Registration and Permits (Air Quality and Fugitive Dust): A separate operating permit is required for each new or existing source. Operating permits shall expire and will be subject to renewal five years after the date of issuance.

Possession of a valid Registration Certificate will be a prerequisite to obtaining the initial operating permit for a new source. Registration Certificates are valid for a 1-year period and require renewal.

Water Quality: Water Pollution Control Regulations for the waters of the State of Nevada were adopted by the State Environmental Commission on October 24, 1973. Existing standards for the State include the revisions adopted April 10, 1973, June 26, 1973, and those of October 24, 1973.

There does not appear to be any activity associated with this solar power plant which would diminish the quality or use class of any natural waters.

Permits and Registration for Waste Discharge: A permit is required from the State of Nevada Bureau of Environmental Health before any person or entity may construct, install, expand, or significantly modify any factory, mill, plant, or other industrial or commercial facility that will result in a waste discharge, not authorized by an existing permit, to waters of the State. This includes facilities used for treatment and/or discharge. The proposed activity will not fall under these provisions according to present plans.

Solid Waste: Although the solar power plant will produce no fuel or process wastes, there will be construction debris and dunnage, which will cause Nevada to have regulatory jurisdiction.

State of Nevada solid waste regulations are included in State of Nevada Regulations Governing Solid Waste Management, adopted January 17, 1973, by the State Board of Health. Authority for regulations and enforcement is contained in the Nevada Revised Statutes. The Regulations further state that nothing contained therein shall be construed to abridge the authority of a town, city, or county to establih by ordinance or otherwise, higher standards than those contained in the State regulations.

General standards for solid waste systems require that all solid wastes shall be stored, collected, utilized, treated, processed, and disposed of in a manner such that a health hazard, public nuisance, or impairment of the environment will not be created. All solid waste systems shall be operated in such a manner so as not to cause or contribute to pollution of the atmosphere, surface, or groundwaters. Solid wastes will not be placed in surface or groundwater or within 4 feet of the highest groundwater table (the health authority may require a greater separation in special cases). No solid wastes handling, processing, salvage, or disposal will be placed in operation unless approved by the health authority.

Solid waste storage, collection, and transportation are to be implemented in such a manner as not to allow the contents to blow, spill, leak or fall. Where spillage does occur, the area is to be properly cleaned and solid wastes returned promptly to the vehicle or container.

Site location will conform to land use planning and not be within 402 m of the nearest inhabited dwelling or place of public gathering or be within 305 m of a public highway unless special provisions for site beautification, litter control, and vector control are included in the design and meet with the approval of the health authority.

Design of the disposal site requires provision for prevention of scattering of papers and other light-weight debris, control of vehicular and livestock access, and control of surface and runoff waters to prevent pooling on top and minimize percolation through filled or working areas.

Operation and maintenance will be in such a manner so as not to create odors, unsightliness, or other nuisances. A minimum, compacted uniform depth of cover material of 61 cm shall be placed on any surface that represents the final grade. Final cover will be graded to drain surface runoff water with a top slope of 2 to 4%. Suitable grasses shall be planted as required in completed areas of the landfill to prevent erosion, surface deterioration, and fugitive dust. Adequate water shall be available at all times for dust control and for compaction of cover material. Access to the land disposal site shall be controlled as to the time of use and as to those authorized to use the site. An attendant shall be on duty to control access during hours of operation.

The Nevada State Health Authority must approve all plans for design, operation, and maintenance of solid waste disposal systems. Application requires a report and design plan. The plan shall be prepared by a properly qualified engineer and shall include a general location map showing land use and zoning within 402 m of the disposal site; and topographic map(s) of the area, which should be at a scale of not more than 1:2400 with contour intervals not exceeding 1.5 m, showing proposed fill areas, borrow areas, access roads, typical cross section of a lift, grades for proper draining of each lift, special drainage, gas control devices if required, fencing, equipment shelter, employee facilities, and all other pertinent data to indicate clearly that the land fill will be developed, operated, and completed in an orderly manner. The report should define who is to be served; anticipated types, quantities, and sources of solid wastes to be disposed of; site geology, hydrology, and soil conditions; source type and quantity of cover material; area water resources, including groundwater elevation and direction of movement; operating procedures; required personnel; and equipment.

Federal Regulations

Air Quality: The U.S. Environmental Protection Agency (EPA) has approved the Air Quality Implementation Plan of the State of Nevada except where it fails to meet signficant deterioration of ambient air requirements.

Fugitive Dust: Federal fugitive dust standards are principally related to occupational health. The Occupational Safety and Health Act of 1970 (OSHA) provides the authority for the United States Department of Labor, Occupational Safety and Health Administration, Occupational Safety, and Health Standards. The fugitive dust standards are presented in Table 1-4.

Permits and Registration for Emissions: The EPA requires a plant review prior to construction. The Administrator is also to be notified 30 days prior to the initial operation with confirmation of action within 15 days after startup. Compliance testing as established by EPA is generally less stringent than for the State of Nevada and Clark County. The numerical values for selected EPA air standards were presented in Table 1-2.

Water Quality: Water quality standards contained in Water Pollution Control Regulations for the waters of the State of Nevada have been preliminary approved with proposed amendments by EPA. There does not appear to be any Federal water quality jurisdiction for this proposed plant.

Solid Waste: Federal regulations for solid waste disposal are contained in Environmental Protection Agency 40CFR241, Guidelines for the Land Disposal of Solid Wastes. The authority for the regulations is provided in Section 209 of the Solid Waste Disposal Act, PL89-272, as amended by PL91-512. The Federal solid waste will be disposed of on Federal lands. The guidelines are also mandatory for Federal agencies. Construction debris and dunnage will be disposed of according to pertinent requirements of 40CFR241, which states that only waste for which the facility has been specifically designed shall be accepted. Generator-owner of excluded waters (hazardous) and the responsible regulatory agency shall jointly determine a method for disposal of excluded wastes.

TABLE 1-4. OSHA STANDARDS FOR FUGITIVE DUST

Substance	Concentration	
	mg/m^3	10^6 particles/m^3
Coal dust (respirable fraction less than 5% SiO_2)*	2.4	—
Coal dust (respirable fraction more than 5% SiO_2)*	$\left(\frac{10}{\%SiO_2 + 2}\right)$	—
Inert or nuisance dust (respirable fraction)	5	530
Inert or nuisance dust (total dust)	15	1767
Crystalline quartz (respirable)	$\left(\frac{10}{\%SiO_2 + 2}\right)$	$\left(\frac{8834}{\%SiO_2 + 5}\right)$
Crystalline quartz (total dust)	$\left(\frac{30}{\%SiO_2 + 2}\right)$	—

*Intent of law is to regulate free silica (crystalline portion; i.e., quartz)

The hydrogeology of the site shall be evaluated in order to design the site development in a manner to protect or minimize the impact on groundwater resources.

Environmental factors, climatological conditions, and socioeconomic factors shall be given full consideration as selection criteria.

The location, design, construction, and operation of the land disposal site shall conform to the most stringent of applicable water standards as established in accordance with or effective under the provision of the Federal Water Pollution Control Act, as amended. In the absence of such standards, the land disposal site shall be located, designed, constructed, and operated in such a manner as to provide adequate protection to ground and surface waters used as drinking water supplies.

The design, construction, and operation of the land disposal site shall conform to applicable ambient air quality standards and source control regulations established under the authority of the Clean Air Act as amended or state and local standards effective under that act, if the latter are more stringent.

Conditions shall be maintained, which are unfavorable for the harboring, feeding, and breeding of vectors.

The land disposal site shall be designed and operated at all times in an esthetically acceptable manner.

In order to conserve land disposal site capacity, thereby preserving land resource, and to minimize moisture infiltration and settlement, municipal solid waste and cover material shall be compacted to the smallest practical volume.

The land disposal site shall be designed, constructed, and operated in such a manner as to protect the health and safety of personnel associated with the operation. Pertinent provisions of the Occupational Safety and Health Act of 1970 (PL91-596) and regulations promulgated thereunder shall apply.

The owner/operator of the land disposal site shall maintain records and monitoring data to be provided as required by the responsible agency.

Permits and Registration for Solid Waste: In addition to the foregoing general criteria, 40CFR241 requires that a solid waste disposal system description address the following in content and format:

a. Types and quantities of all wastes
b. Site development plans prepared or approved by a professional engineer
c. Initial and final topographies at intervals of 1.5 m or less

d. Land use and zoning within 402 m of the site including location of all residents, buildings, wells, water courses, arroyos, rock outcroppings, roads, and soil and rock borings

e. Location of all utilities within 153 m of the site

f. Employee convenience and equipment maintenance facilities

g. Narrative description, with associated drawings indicating site development and operation procedures

h. Description of the project use of the completed land disposal site

i. Current and projected use of water resources in the potential zone of influence

j. Groundwater elevation and movement, and proposed separation between the lowest point of the low [illegible] cell and the predicted maximum water table elevation

k. Potential interrelationship of the land disposal site, local aquifers, and surface waters based on historical records or other sources

l. Background and initial quality of water resources in the potential zone of influence

m. Proposed location of observation wells, sampling stations, and testing programs planned, where appropriate

n. Description of soil and other geologic material to a depth adequate to allow evaluation of the water quality protection provided by the soil and other geologic material

o. Provision for surface water runoff control to minimize infiltration and erosion of cover material

p. Potential of leachate generation and proposed control systems where necessary to protect ground and surface waters

q. If the site is located in a flood plain, it shall be protected against at least the 50-year design flood by impervious dikes and other appropriate means.

As stated earlier rainwater runoff from any material storage pile must be collected and treated to limit the concentration of pollutants to: TSS, not to exceed 50 mg/ℓ and pH within the range 6.0 to 9.0.

Land Use: Federal standards require that the lands managed by the Bureau of Land Management for which an applicant requests development be specifically designated as other than resource land inventory. This requirement is implied and specific in the National Environment Policy Act, and the guidelines for Federal agencies promulgated under the act.

Noise: The United States Department of Labor has developed guidelines under the authority provided in OSHA. The standards applicable to the construction and operation of this project allow such high noise levels as to be irrelevant to the project.

1.6 REFERENCES

1-1. Davidson, Joseph K., and H. Lundgren. Letter report to Spectrolab, Inc., on a "Conceptual Design of a Photovoltaic Central Station Power Plant (Module)," Ingenasu Associates, Tempe, Arizona, May 1976.

1-2. Bechtel Corporation. A Preliminary Report on a Conceptual Design of a Central Station Power Plant. Prepared for Spectrolab, Inc., under Subcontract No. 66725, San Francisco, California, January 1976.

1-3. Chilenskas, Albert A., Argonne National Laboratory, Argonne, Illinois. Private communication with D. Richard Sears of Lockheed-Huntsville, June 1976.

1-4. Anon: Kaiparowits Power Project Dropped. Coal Age, May 1976, p. 25.

SECTION 2
ENVIRONMENTAL SETTING WITHOUT THE PROJECT

Note: The assigned scope of this task specifically demands reduced emphasis on background information, historical trends and socioeconomic analyses. Therefore, this section represents about the very minimum material that an interested reader would need in order to proceed independently with even the most perfunctory analysis. The corresponding portions of Sections 3, 4, and 6 through 11 will be even briefer.

2.1 LOCATION

Units 1 and 2 comprise, respectively, 25.1 and 54.88 km^2 tracts, located on either side of Dry Lake, about 32 km northeast of Las Vegas, Nevada. Figure 1-1 places the facility with respect to major political and geographical features of the U.S. Southwest. Figure 2-1 presents an overlay of the plant boundaries upon the U.S. Geological Survey map NJ11-12 (1969) "Las Vegas." Depicted in the figure are not only units 1 and 2, described in Section 1, but also the perimeter of a possible alternative site. (The latter is referred to in Section 2.9 "Ecological Setting." In Sections 1 and 5, some implications of a split site are identified. It is beyond the scope of this task to analyze the relative advantages and tradeoffs in detail since very much less baseline data are immediately available.)

Unit 1 would occupy all or part of sections 22, 23, 24, 25, 26, 27, 34, 35, and 36 of T. 17S, R63E; sections 1, 2, 3, 10, 11, 12 and 13 of T.18S, R63E; and sections 6 and 7, T.18S, R64E. Elevations are 610 to 720 m above MSL.

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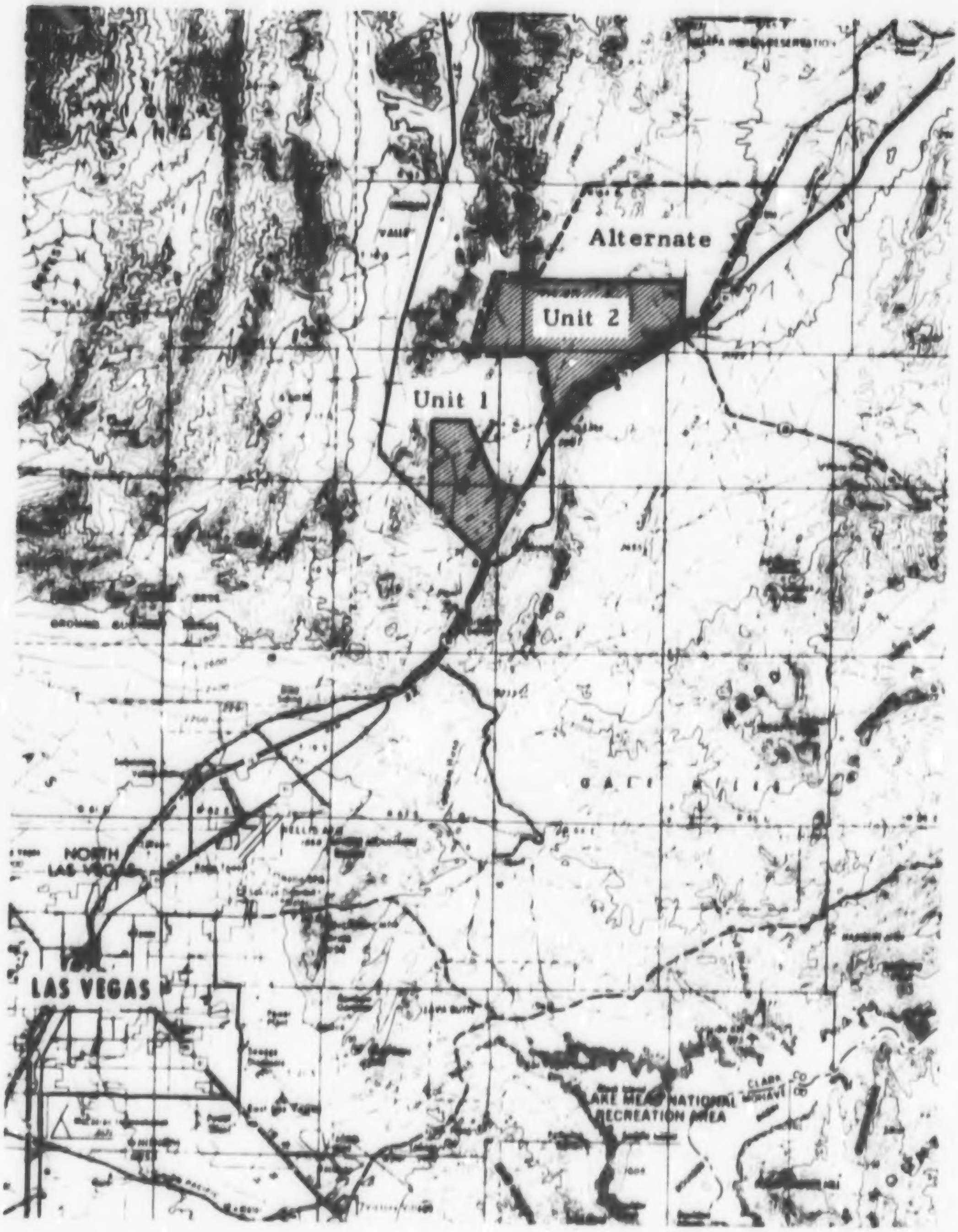
Alternate
Unit 2
Unit 1
NORTH LAS VEGAS
LAS VEGAS
LAKE MEAD NATIONAL RECREATION AREA
CLARK
MOHAVE

Figure 2-1. Relationship of the plant site to topographic features.

Unit 2 is proposed to occupy all or part of sections 24, 25, 26, 35, and 36 of T.16S, R.63E; sections 19-36 of T.16S, R.64E; and 8, 9, 10, 11, 15, 16 and 17 of T.17S, R.64E. Elevations are 610 to 720 m above MSL.

The alternative site is continuous with unit 2, includes all of it, and in addition extends northward and eastward to include all or part of sections 1-13 (except 6) of T.16S, R.64E; 4, 5, 6, 7, 8, 17, 18, 19, 20, and 30 of T.16S, R. 65E. Elevations are 610 to 781 above MSL, (excluding hills to 854 m in sections 2, 3, 10 and 11 of T.16S, R.64E).

Located between these two units is Dry Lake, an alkali flat depression which is not suitable for construction because it floods to depths of several meters every few years. Standing water disappears in a few months.

2.2 REGIONAL DEMOGRAPHIC, SOCIOECONOMIC, AND COMMUNITY CHARACTERISTICS

(The material which follows is largely from the Harry Allen Station Environmental Assessment, Ref. 2-1. Very detailed and extensive baseline data are contained in that assessment, which may be regarded as supplementary to this section.)

Historic Population and Population Projections

The major population center in the study area is the city of Las Vegas, which in 1974 had an estimated population of 146,900 or 42% of the population of Clark County, which had 349,000 persons (Table 2-1). The city of Las Vegas has been a major population growth center since World War II. Since 1940, when 8432 persons were counted, the population of Las Vegas has grown exponentially. North Las Vegas, a functional part of the metropolis, has had similar growth.

Henderson, in Las Vegas Valley, and communities in the Moapa Valley have experienced fluctuating and declining population. The locations of these communities are not shown in Figure 2-1. They are just NE of the NE corner of that map.

TABLE 2-1. HISTORICAL POPULATION*

Location	1940	1960	1970	July 1, 1973	July 1, 1974
Las Vegas Valley					
Las Vegas	8,432	64,405	125,787	135,355	146,900
North Las Vegas	—	18,422	36,216	41,400	45,000
Henderson	—	12,525	16,395	17,650	16,500
Moapa Valley					
Glendale	—	—	—	70	(**)
Logandale	—	809	426	395	(**)
Moapa	—	432	353	41	(**)
Overton	—	1,162	1,336	1,292	(**)
Total Clark County	16,414	127,016	273,288	331,700	349,000
State of Nevada	110,247	285,278	488,738	559,316	583,563

*Sources: Clark County Regional Planning Council, Nevada Bureau of Business, and Economic Research.

**No estimate made.

Several population projections for Clark County have been developed. They cover a very wide spectrum of future population levels due to differences in assumptions, forecast techniques, and sophistication. A number of the population projections for Clark County are presented in Figure 2-2.

Employment Characteristics and Labor Force Inventory

As analyzed by the Nevada Employment Security Department, the geographical labor market area consists of Clark County and Beatty Township of Nye county. Together, these areas comprise the Las Vegas Standard Metropolitan Statistical Area (SMSA). Beatty Township is included in the normal Las Vegas SMSA because it contains most of the Nevada Test Site and the Nuclear Rocket Development Station where historical employment peaks

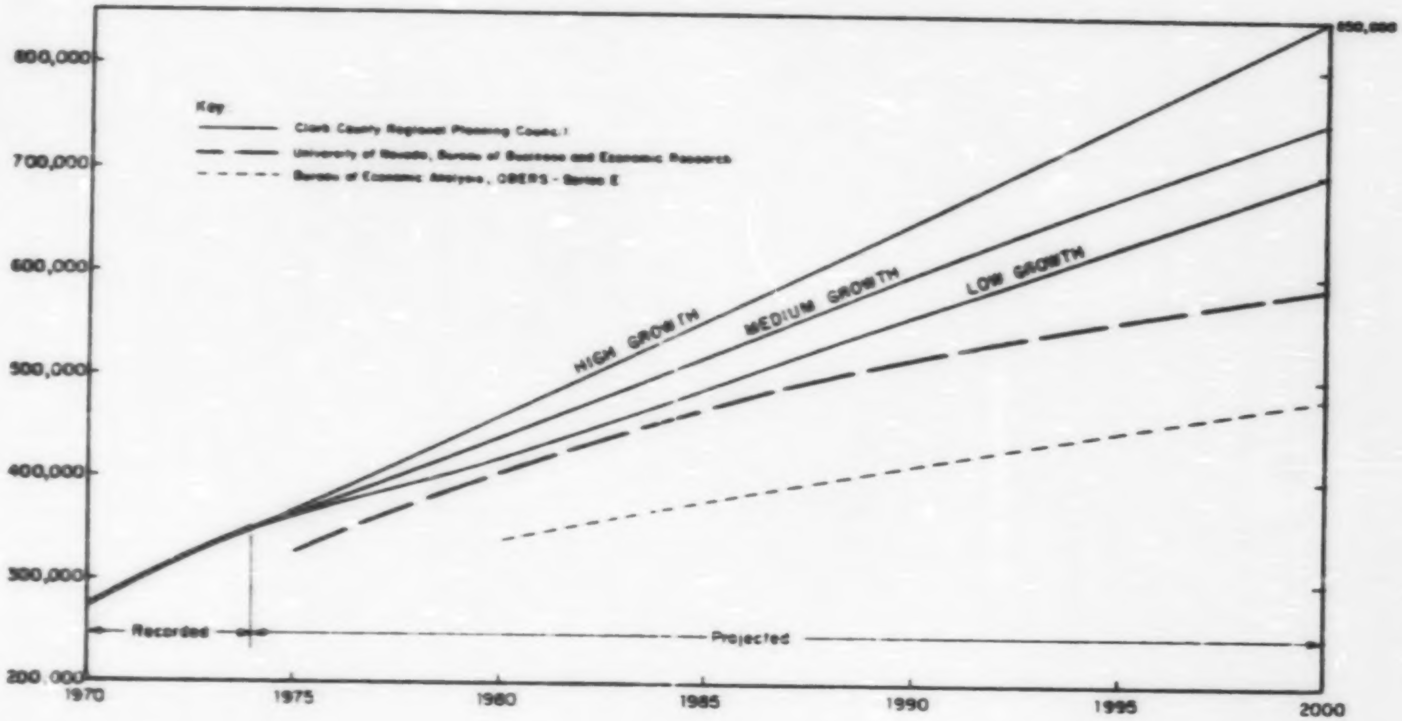

Figure 2-2. Projected population – Clark County, Nevada.

have reached 10,000 persons. These two nuclear-related facilities had a combined employment of 5,300 persons in March 1975.

Since 1960 the service industries (personal, business and hotels, gaming, and recreation) have engaged the largest percentage of the total civilian labor force (TCLF). Manufacturing has not provided much employment, and in March 1975 employed only 3.1% of the TCLF. Likewise, the agricultural and mining sectors employ a very small percentage of the TCLF. Currently, the fourth largest segment of the civilian labor force is unemployed. The 18,000 persons out of work, but still in the labor force, represent 11.3% of the TCLF. Details are presented in Table 2-2. In Table 2-3, a breakdown is given of construction-related crafts union membership, indicative of the labor force available for plant construction. Table 2-4 presents employment projections, presumed to include all major anticipated construction projects, including power plants.

Family Income

Family income levels for both the State of Nevada and Clark County are well above national figures. The major source of family income is wage and salary income with 63,609 families in Clark County averaging $11,219 of income. Self-employment generated an average income of $8,632 for 5,564 families. The per capita money income for the State of Nevada was $3,554 in 1970 and $3,538 for Clark County. The national average was $3,119.

The average annualized wage of all classes of construction and operating personnel employed at this hypothetical plant would exceed the Clark County average very substantially.

Community Infrastructure

In 1974, Clark County contained four cities, nine towns, one school district, four special school districts, and 12 nonschool special districts. Cities provide urban facilities and services such as streets, public safety, sewage, and refuse disposal, among others. Special districts in Clark County provide

TABLE 2-2. LABOR FORCE, BY INDUSTRIAL SECTOR (LAS VEGAS SMSA – 1960, 1970, 1975)[*]

	Personnel (thousands)		
Occupation Group	1960[**]	1970[**]	March 1975[†]
Services	20.9	51.1	68.3
Trade	8.4	21.2	26.8
Construction	3.7	7.2	9.2
Manufacturing	2.6	4.2	4.9
Transportation and Public Utilities	3.8	7.2	8.7
Finance, Insurance and Real Estate	1.4	4.1	5.7
Government	6.2	16.3	19.5
Mining	0.4	0.1	0.2
Agriculture	0.5	0.4	0.7
Other	5.8	9.7	- -
Unemployed	3.0	7.1	18.0
Total Employment	53.7	121.5	139.5[††]
Total Civilian Labor Force	56.7	128.6	157.5

[*] Source: Manpower Report. Nevada Employment Security Department, 1975.

[**] Annual average.

[†] Established-Based Industrial Employment. Reflects employment by place of work. Does not necessarily coincide with Labor Force concept. Includes multiple jobholders.

[††] Adjusted by census relationship to reflect number of persons by place of residence.

TABLE 2-3. UNION MEMBERSHIP

Craft	Membership
Asbestos workers	160
Boilermakers	400
Bricklayers	160
Carpenters	800
Cement masons	320
Electricians	960
Ironworkers	320
Laborers	1600
Linemen	160
Millwrights	400
Operating engineers	800
Painters	480
Pipefitters	800
Sheet metal workers	560
Teamsters	1200
Total	9120

TABLE 2-4. EMPLOYMENT PROJECTIONS, LAS VEGAS SMSA (1980-2000)

Source	1980	1990	2000
Department of Commerce, Bureau of Economic Analysis (1972) (OBERS Series E)	157,000	186,000	214,100
Nevada Employment Security Department	216,000		
Clark County	H 204,000	333,000	377,000
Regional Planning	M 193,000	266,000	333,000
Council (1972)	L 186,000	248,000	311,000

services such as fire protection, water, sanitation, and libraries. School districts also function independently to administer public education at the local level. Detailed descriptions of the housing availability, vacancies, etc., are contained in Ref. 2-1.

Education

Schools in Clark County are slightly underutilized (Table 2-5) and an influx of construction workers might be expected to impact school enrollment. However, projected growth patterns overwhelm the small contribution due to the small work force anticipated for this project (Table 2-6).

The University of Nevada at Las Vegas (UNLV) is the second largest education system in Nevada with an estimated 18,725 students and 621 professors in fall 1974. It is anticipated that a law school will open on the campus in the fall of 1976.

Clark County Community College was founded in 1971 with an appropriation from the State Legislature of $442,000. In 1973, there were 850 students in career development programs. The college anticipates a $2 million campus and a student body of 3,000 in its three-part master plan.

Very few construction craftsmen would be expected to request evening continuing education service from these two schools. Engineering personnel, perhaps even during construction, however, might request professional courses.

Hospital Facilities

Health services in Clark County are provided by a system of nine hospitals with a total of 1,579 beds. The ratio is approximately five beds per 1,000 population. Most of the facilities provide for out-patient as well as 24-hour emergency services. In addition to the nine hospitals, the area has several childrens' clinics and numerous convalescent homes.

TABLE 2-5. SCHOOL CAPACITY AND ENROLLMENT, CLARK COUNTY SCHOOL DISTRICT (1973-1974)*

Attendance Area	Capacity**	Enrollment	Difference
Las Vegas	70,123	69,491	632
Henderson	4,955	4,686	269
Boulder City	1,532	1,662	(90)
Moapa Valley	1,051	756	295
Virgin Valley	400	345	55
Indian Springs	493	359	134
Rural	148	118	30
Total County	78,702	77,377	1,325

*Source: Clark County School District, 1973, "Master Plan."

**Capacities based on utilization factors of: (1) 100% at the K-6 grade level and special education; (2) 90% at the 7-8, 7-9 and 9-12 grade levels; and (3) 85% at the 10-12 grade level.

TABLE 2-6. PROJECTED SCHOOL BUILDING NEEDS, BY ATTENDANCE AREA, CLARK COUNTY SCHOOL DISTRICT*

Attendance Area	Projected Building Needs
Las Vegas	5 elementary schools, 2 junior high schools, 1 high school
Henderson	14 elementary classrooms
Boulder City	10 elementary classrooms, 8 junior/senior high classrooms
Moapa Valley	2 classrooms
Virgin Valley	2 classrooms
Indian Springs	2 classrooms
Rural	No additional facilities required

*Source: Clark County School District, 1973, "Master Plan."

Transportation

Transportation facilities for passenger and freight in Clark County include air facilities, a highway system, interstate bus transit, surface transit and railroad freight. The railroad currently serves Las Vegas with freight stops (12 to 15 daily) for freight movement and crew changes.

Two modes of transportation which have expanded throughout the years are air and highway transportation. McCarren International Airport at Las Vegas, was completed in 1974. It provides passenger and cargo service through scheduled airlines (Air West, Delta, Frontier, National, TWA, United and Western), third level carriers, supplemental carriers including charter flights, and general aviation.

There are six major highways in Clark County; Interstate Highway 15 north to Salt Lake City, U.S. Highway 95 north to Tonopah-Reno, U.S. Highway 95 south to Searchlight, U.S. Highway 93 south to Kingman, Interstate Highway 15 south to Los Angeles, and U.S. Highway 93 north to Idaho. Traffic counts for 1973 show Interstate Highway 15 south having an average daily traffic volume of 10,850 vehicles, while Interstate Highway 15 north, near the proposed site, handled 5,550 vehicles daily.

Three interstate bus lines serve Las Vegas: Greyhound and Sun Valley, Continental, and Las Vegas-Tonopah-Reno Stage. The total passenger volume for 1971 was nearly 1.5 million passengers. The privately owned and operated Las Vegas Transit System provides service to major portions of the Las Vegas Valley, primarily for tourists.

The 1973 annual report of the transportation study reflected the importance of land use analysis as a factor in planning and forecasting future urban requirements; namely, increases in population, business and industrial growth, schools, and parks, while reducing uneconomical sprawl or isolated pockets of development in future traffic patterns.

Electrical Energy

Nevada Power Company, which serves Clark and Nye counties, experienced a 4.3% increase in electric energy sales in 1974. Electric energy usage statistics for 1972-74 are given in Table 2-7.

TABLE 2-7. ELECTRIC ENERGY USAGE*

Item	1974	% of change	1973	% of change	1972
Sales (1000 kWh)					
Residential	1,814,638	+1.2	1,792,688	+12.8	1,589,667
Commercial and Industrial	2,132,143	+7.5	1,983,701	+ 9.1	1,819,023
Other	295,770	+1.8	290,422	+17.1	248,117
Total	4,242,551	+4.3	4,066,811	+11.2	3,656,807
Customer Accounts	113,021	+4.6	108,088	+ 8.1	99,996

*Source: Greater Las Vegas Chamber of Commerce. 1975.

Other

Reference 2-1 contains detailed discussions and data concerning:

- Public Safety
- Utilities
- Natural Gas
- Public Finance and Taxation
- Power Company Appraisals and Tax Liabilities
- Pending Tax Legislation
- Tourist/Convention Industry
- Service Industries
- Agriculture and Mining

and other topics related to secondary socioeconomic impacts of plant construction.

2.3 WATER RESOURCES, USE AND QUALITY

The material in this section is extracted from the much more detailed report in Ref. 2-1.

Supply and Use

Natural springs in the Las Vegas Valley and flow from artesian wells had to be augmented by pumping in 1941 to keep pace with increased water consumption due to increased urbanization. Residential and transient use of water accounts for 62% of water withdrawals in the Las Vegas Valley.

For 1973, 86.3×10^6 m^3 were withdrawn from groundwater, 92.4×10^6 m^3 were withdrawn from the Colorado River, and 11.7×10^6 m^3 were recycled from wastewater. Trends in water use from 1969 to 1973 show a decrease in groundwater extraction, slight increases in wastewater reuse, and significant increases in diversions of Colorado River water (cf. Table 2-8). Projections of water consumption in the year 2000 show a doubling of water demand if the projected 700,000 population is attained.

Colorado River water represents the major water source for the Las Vegas Valley. The 1964 U.S. Supreme Court ruling in the case of the State of Arizona versus the State of California established the amount of Colorado River water allocated to the State of Nevada. This ruling provided for a 1.31×10^{10} m^3/yr allotment to Nevada if sufficient mainstream water is available for release.

Not all of this total entitlement is available to the Las Vegas Valley due to other commitments. Table 2-0 lists the projected distribution of Nevada's allotment of Colorado River water. In order to meet the area's growing water needs as well as to relieve excessive dependence on groundwater, the Colorado River Commission of Nevada undertook the southern Nevada Water Project, designed to provide 1.31×10^{10} m^3 of Colorado River water for domestic and industrial use. The first phase of the project was completed in 1971 and the total of 5.76×10^9 m^3 of water was distributed through various agencies, as shown in Table 2-10.

TABLE 2-8. WATER USES AND SUPPLY DISTRIBUTIONS – LAS VEGAS VALLEY (1973)*

Parameters	History for Year 1973 With Estimated July 1, 1973 Population of 316,725 People acre feet	10^9 m^3
Water Used		
Potable Water –		
Residential and Transient	90,000	3.92
Parks and Public Facilities	9,200	0.40
Golf Courses	6,100	0.27
Agriculture	3,000	0.13
Heavy Industry	13,600	0.59
Commercial and Light Industry	20,000	0.87
Military	3,200	0.14
Total Potable Water Used	145,100	6.32
Reclaimed Wastewater –		
Parks and Public Facilities	0	0
Golf Courses	1,200	0.05
Agriculture	4,500	0.20
Power	3,700	0.16
Total Reclaimed Wastewater Used	9,400	0.41
Total Water Used	154,500	6.73
Water Supplied		
Groundwater Withdrawals	70,100	3.05
Colorado River Diversions	75,000	3.27
Reclaimed Wastewater	9,400	0.41
Total Water Supplied	154,500	6.73

*Source: Nevada Environmental Consultants, 1974

TABLE 2-9. PROJECTED DISTRIBUTION OF NEVADA'S ALLOTMENT OF COLORADO RIVER WATER*

		Allotment, acre feet/yr**			
Year	Water Available†	Fort Mohave Steamplant	Fort Mohave Land Develop.	Federal	For use in Metro L. V. Sub-Area††
1970	300,000	Nil	Nil	1,000	299,000
1980	300,000	30,000	8,000	2,000	260,000
1990	300,000	25,000	13,000	4,000	258,000
2000	300,000	15,000	13,000	6,000	266,000
2010	300,000	Nil	13,000	6,000	281,000
2020	300,000	Nil	13,000	6,000	281,000

*Source: Nevada State Engineer (1971) as reported in Nevada Environmental Consultants. 1974. Facilities Plan Pollution Abatement Project Las Vegas Wash and Bay, Annex A.

**1 acre-foot = 43560 m^3.

†Does not include credit for return flow.

††Includes water delivered through facilities of Southern Nevada Water Project, Boulder City, and BMI.

TABLE 2-10. PHASE I SOUTHERN NEVADA WATER SYSTEM DELIVERY COMMITMENTS*

Agency	10^9 m^3/yr	Percent of Total
Las Vegas Valley Water District	4.32	75
City of North Las Vegas	0.87	15
City of Henderson	0.30	5
Nellis Air Force Base	0.17	3
Boulder City	0.09	2
Total	5.76	100

*Source: Nevada Environmental Consultants, 1974.

Based upon the construction of Phase II facilities and the availability of Colorado River water, options for additional deliveries through the Southern Nevada Water System were extended to those agencies listed in Table 2-11.

TABLE 2-11. PHASE II: SOUTHERN NEVADA WATER SYSTEM DELIVERY OPTIONS*

Agency	10^9 m^3/yr	Percent of Total
Las Vegas Valley Water District	4.36	60
City of North Las Vegas	0.87	12
City of Henderson	1.44	20
Boulder City	0.57	8
Total	7.27	100

*Source: Nevada Environmental Consultants, 1974

The State of Nevada annual entitlement of 13.07 x 10^9 m^3 may be exceeded in any given year by the amount of water returned to the Colorado River System.

Treatment and reclamation of wastewater provides a third significant water resource. Statistics for 1973 revealed that wastewater reuse in Las Vegas Valley approximated 11.7 x 10^6 m^3 of a total 64.7 x 10^6 m^3 available for reclamation and reuse. The amount of wastewater available for reuse is expected to increase proportionately with future population growth within the Las Vegas Valley.

The 1974 report by Nevada Environmental Consultants (NECON) entitled Facilities Plan Pollution Abatement Project Las Vegas Wash and Bay, Annex A, provides a comprehensive description of water resource uses and needs within the Las Vegas Valley. This report has been adopted by the Clark County Board of Commissioners and has been utilized for source data for this discussion of present and projected water needs within the Las Vegas Valley.

Projections of water needs and supply distributions for the year 2000 are given in Table 2-12. NECON (Nevada Environmental Consultants) used the Clark County Regional Planning Commission population projections for both medium and high growth within the Las Vegas Valley. Assuming a population level of 700,000, water needs will more than double by the year 2000. Groundwater withdrawals will continue to decrease, but there will be significant increases in Colorado River diversions and reclaimed wastewater use when the proposed Advanced Wastewater Treatment Plant becomes available.

Surface Water

Except at times of unusual rainfall, no material surface water exists in the vicinity of Units 1 and 2. The occasional flooding of Dry Lake and its ecological consequences is discussed in Section 2.9.

Groundwater

A geohydrologic investigation of Dry Lake Valley was made in 1972 to determine the suitability of the playa as a disposal site for wastewater from the Las Vegas area. No field investigation of groundwater conditions was made for the present study. Groundwater quality fails to meet U. S. Public Health Service Standards with respect to at least one component for each test well analyzed (Ref. 2-1). See Table 2-13.

Dry Lake Valley Basin: The Paleozoic carbonate rocks and the alluvial deposits of Dry Lake Valley are relatively permeable and will yield water to wells where saturated. The Muddy Creek Formation and the Playa silts and clays in the central portion of the basin are nearly impermeable, and act as aquicludes. Lithology of these units is discussed in detail in Ref. 2-1.

Only three water wells within the Dry Lake Valley are known to penetrate the limestone rocks. Construction data for these wells is unknown and it is not known if production is from the limestone or overlying sediments. However, it is believed that at least a portion of the water yielded to these wells comes from the limestone rocks. The carbonate rocks which comprise

TABLE 2-12. WATER NEEDS AND SUPPLY DISTRIBUTIONS – LAS VEGAS (2000)*

Parameters	Projections for Year 2000			
	For Medium Population of 700,000		For Maximum Population of 805,000	
	acre** feet	billion** gallons	acre** feet	billion** gallons
Water Needs				
Potable Water Needs				
Residential and Transient	212,800	69.34	244,700	79.74
Parks and Public Facilities	10,000	3.26	13,200	4.30
Golf Courses	6,000	1.96	6,100	1.98
Agriculture	3,000	0.98	4,000	1.31
Heavy Industry	32,200	10.49	32,600	10.62
Commercial and Light Indus.	46,900	15.28	53,900	17.56
Military	7,700	2.50	8,900	2.90
Total	318,600	103.81	363,400	118.41
Reclaimed Wastewater Needs				
Park and Public Facilities	11,000	3.58	11,000	3.58
Golf Courses	9,800	3.20	11,800	3.85
Agriculture	8,500	2.77	8,500	2.77
Power	39,500	12.87	39,500	12.87
Heavy Industry	-0-	-0-	4,400	1.43
Total	68,800	22.42	75,200	24.50
Total Water Needed	387,400	126.23	438,600	142.91
Water Supplies				
Groundwater Withdrawals	50,000	16.29	50,000	16.29
Colorado River Diversions	268,600	87.52	313,400	102.12
Reclaimed Wastewater+	68,800	22.42	75,200	24.50
Total Water to be Supplied	387,400	126.23	438,600	142.91

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*Source: Nevada Environmental Consultants, 1974.

**1 acre-foot = 43560 m^3; 10^9 gallons = 3.785×10^6 m^3.

+Contingent upon completion of Advanced Wastewater Treatment Plant.

TABLE 2-13. GROUNDWATER QUALITY, DRY LAKE VALLEY, CLARK COUNTY, NEVADA*

Standard Mineral Constituents, mg/ℓ		Heavy Mineral Constituents, mg/ℓ	
Ca	11-131	As	Tr - 0.078
Mg	0-84	Ba	0.04 - 0.075
K	16-93	Cd	0.003 - 0.016
Na	129-516	Cr	0.007 - 0.024
K + Na	9-154	Cu	0.014 - 0.034
CO_3	0-600	Pb	0.037 - 0.112
HCO_3	0-278	Mn	0.05
Cℓ	120-378	Hg	0.001 - 0.0017
SO_4	19-700	Se	0.002 - 0.0096
NO_3	0-71	Ag	0.008 - 0.028
F	1.4 - 4.3	Zn	0.089 - 1.86
B	0.09 - 0.65		
Alkalinity as $CaCO_3$	28-878		
Fe	0.01-20		
TDS	350-3000		
SiO_2	23-25		
Turbidity (J.U.)	0-97		
pH	7.5-11.5		
Color	0-15		

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*Data are extrema of data for all test wells reported in Ref. 2-1.

the major portion of the surrounding hills are present to unknown depths beneath the basin, and extend beyond into adjacent basins. Permeability of these rocks is considered moderate to high due to open fractures and joints. Solution cavities and openings have been observed in surface outcrops; southern Nevada is known to have cavernous limestones. The balance of wells in the valley extract water from the alluvial deposits that surround the interfinger with Muddy Creek and playa deposits.

Permeability of the alluvium is probably greatest in the southern portion of the valley where the materials are derived almost entirely from erosion of the limestone, and little is derived from the Muddy Creek formation.

Groundwater Occurrence and Levels: Within Dry Lake Valley, data on groundwater are available from only nine water wells, of which only two are active. Additional data are provided by two observation wells. Three of the water wells penetrate Permian sandstone and/or limestone basement rocks as reported by driller's logs. Groundwater extractions from the two active wells is estimated to be about 2.18×10^6 m^3/yr.

Groundwater levels and elevations within Dry Lake indicate the gradient is nearly flat and suggest minor amounts of groundwater flow.

Within the study area, the amount of groundwater recharge is small. Only the southern and western alluvial fans within Dry Lake Valley are sufficiently permeable to accept large quantities of water by percolation. Waters that infiltrate the alluvium outside the extent of the playa clay may reach the regional groundwater system. Where infiltrating water encounters the playa and Muddy Creek clays, it may form local perched groundwater systems. It is estimated 35×10^6 m^3 of water is recharged to Dry Lake Valley annually. This figure includes both alluvial and carbonate rock areas.

In a closed basin, such as Dry Lake Valley, recharge to the groundwater will cause water levels to rise until there is discharge by subsurface outflow, or by surface discharge to the floor of the playa. The groundwater surface has not been raised sufficiently to reach the playa surface. Subsurface outflow may be occurring when water levels attain an elevation above 556 m.

Interbasin movement of groundwater through the carbonate rocks is considered possible. For Dry Lake Valley, the extremely flat gradients and general lack of data preclude any definitive determination of the direction or quantity of such movement. Studies by the U. S. Geological Survey have shown interbasin movement of groundwater to be occurring in basins of southern Nevada.

Water Quality and Use: Ranges of water quality analyses of samples taken from wells in Dry Lake Valley are shown in Table 2-13. All but one of the samples are from the alluvial aquifer; the exception is apparently from the carbonate aquifer. These data indicate the quality of the groundwater in the Dry Lake Valley is generally poor for drinking purposes. The United States Public Health Service Drinking Water Standards (1963) of permissible levels of constituents are exceeded for at least one of the several constituents in each well. These include nitrate, cadmium, lead, manganese, fluoride, iron, and total dissolved solids. Salinity ranges from about 350 to 1730 ppm and averages about 1100 ppm.

The mineral constituents of the waters vary from sodium sulfate, to calcium sulfate-chloride, to calcium sulfate. This probably reflects leaching of gypsum and base exchange of clay minerals in the playa alluvium and Muddy Creek Formation.

2.4 SANITATION AND WASTE MANAGEMENT

This material is quoted from Ref. 2-1.

Wastewater Treatment

Wastewater in Clark County is managed by the city of Henderson, city of Las Vegas, city of North Las Vegas, Clark County Sanitation District, and Basic Management, Inc. Most of the facilities are reported to require renovations to enhance treatment capabilities and expansions to accommodate continued urban growth. The treatment plant in Henderson is reportedly obsolete and its expansion is not economically feasible.

The cities of Las Vegas and North Las Vegas operate a joint treatment plant with the design capacity of 1.14 x 10^5 m^3/d. An average flow of 8.74 x 10^4 m^3/d was recorded in 1973. The present plant location is able to accommodate additional facilities including tertiary treatment installations.

The Clark County Sanitation District is under the control of the County Board of Commissioners. The District's service area covers over 414 km^2 of unincorporated urban fringe areas. Current average daily flow at the county sewage treatment plant is 8.3 x 10^4 m^3/d. At the present rate of growth demands on the District's facilities are expected to reach the average design capacity in about 5.5 years. The annual per capita cost of sewer service in Clark County was $10.40 in 1972.

Solid Waste

Solid waste disposal in the cities of Las Vegas, North Las Vegas, Henderson, and Boulder City is managed by mandatory subscription to a private contractor. Voluntary subscription service is available to residents of other small communities. Approximately 85% of Clark County residents receive solid waste collection service.

Sunrise Mountain Sanitary Landfill, located about 13 km northeast of McCarran International Airport, is the largest of 24 disposal sites in Clark County. In 1973, over 259,000 MT of solid waste were disposed of at the site, representing 96% of all solid wastes generated in Clark County.

Las Vegas Valley residents generate about 1.6 kg of solid waste per capita per day while commercial establishments generate about 1.1 kg per capita per day. Tourist activities in hotel-casinos generate approximately 0.34 kg of solid waste per capita per day.

Solid waste generation cost factors for 1973 were estimated at $12.54/MT residential service and $25.42/MT for commercial service. Projected annual total solid waste quantities based upon projected trends in unit rates of solid waste generation and Clark County Regional Planning Council medium-growth population projections are 454,000 MT in 1980; 680,000 MT in 1990; and 907,000 MT in 2000.

2.5 LAND USE

This facility will require the hypothetical dedication of about 52 km^2 for a prolonged, perhaps indefinite, period. The projected life of the plant is 30 years, preceded by phased construction over 10 years, resulting in a minimum commitment of 40 years. Careful appraisal of current and future land use practices near the site and in the vicinity is required.

The two units, illustrated in Figure 2-1, are separated by the Dry Lake depression shown on current topographic maps. Historically the area accumulates alkali water from rain run-off every two to three years, and has reached depths of 1.2 to 1.5 m. This flooding precludes siting of either solar modules or ancillary electrical equipment and structures on the lake.

Land uses throughout the study area are relatively scarce. Transmission lines and transportation corridors are predominant in the valleys. There are few industrial mining land uses, or dwellings near the study area.

Many of the remaining land uses near the proposed sites are designated parks, natural areas, or recreation resources, and are generally located in the mountainous areas.

Rural Residential: Approximately seven structures are located adjacent to the Dry Lake between the original U.S. Highways 91 and 93 road alignment and Interstate Highway 15. Only two of these are still inhabited. One mobile home trailer is situated south of Dry Lake adjacent to U.S. Highway 93.

__Transportation and Utility Corridors__: Numerous transportation and utility corridors are presently located within the study area.

A. Highways

1. Interstate Highway 15 passes in a southwest to northwest direction through the Dry Lake Valley. The 1973 daily traffic volume for this portion of Interstate Highway 15 was 5025.
2. U.S. Highway 93 is a paved state primary highway that is routed north-to-south through Hidden Valley between Las Vegas and Arrow Canyon Ranges. Traffic volume in 1973 averaged 550 vehicles per day.
3. Nevada State Highway 40, a secondary highway connecting Interstate Highway 15 with Nevada State Highway 12, provides access into Valley of Fire State Park. This highway crosses through the northern part of the study area. Daily traffic volumes averaged 100 in 1973.

B. Railroads

The Union Pacific Railroad is routed in a generally south-north direction, through Dry Lake Valley, passing adjacent and west of the Dry Lake Range. An auxiliary railroad spur that connects an industrial plant to the main railroad is routed east of the Las Vegas Dunes Recreation Area, located in the southern part of the study area.

C. Transmission Lines

1. The study area is crossed by four transmission lines. Two parallel, 230 kV, wood-pole lines that originate at the Reid Gardner Station north of the study area, pass southwest through Dry Lake Valley and connect to a substation located in the northern part of Las Vegas Valley.
2. The Navajo-McCullough 500 kV lattice tower line parallels the 230 kV lines north of the Dry Lake Valley. The line diverges north of the Dry Lake Range, crossing Interstate Highway 15 and passing east of the Dry Lake Mountain Range in a southerly direction through the valley and portions of the Muddy Mountains.
3. An H-frame, wood-poled, 69 kV line parallels U.S. Highway 93 through Hidden Valley. This line, following a southern route through mountainous topography, connects to a small substation and continues into the Las Vegas Valley.

Heavy Industry: The Apex Mining and Processing Plant is a lime mining and processing facility, located on the west side of Interstate Highway 15 south of Dry Lake Valley. It is a large-scale, heavy industrial land user, encompassing 162 hectares.

Agriculture: Agricultural activities produce a minimal input to the Clark County economy. Agricultural employment was about 700 persons in March 1975. The utilization of migrant workers to supplement local labor supply tends to cause employment fluctuations during harvest periods. The Moapa Valley (64 km northeast of the plant site) constitutes the primary agricultural area within Clark County. This narrow, 16 km long valley bordering the Muddy River produces sugar beet seeds, tomatoes, radishes and green onions. The dairy industry of Clark County is also located in the Moapa Valley. In 1969, the last year for which data are available, there were only 159 agricultural operations (1.9% of land area) of all types in Clark County. The productivity of the region is so low that the farm value (1969 dollars) was only $610/hectare, including both land and buildings.

At the plant site there is no agricultural activity of any sort. The hard pan (caliche) is reported to be only 25 to 46 cm below the surface. Further, there is a 5 to 8 cm deep vesicular layer at the soil surface which reduces downward heat penetration and dissipation. Consequently, the plant area has no potential agricultural productivity whatsoever, even with irrigation, now or in the foreseeable future (Ref. 2-2).

Mining: The mineral industry in Clark County has experienced pronounced fluctuations due both to external demands and mineral discoveries. Discoveries of gold and magnesium have caused periodic increases in mining activities since 1906.

The annual value of total mineral production in the State of Nevada and Clark County was $\$120.4 \times 10^6$ and $\$12.3 \times 10^6$, respectively.

Gypsum is the major mined mineral resource in Clark County. Major gypsum mining activities are carried out by the U.S. Lime Products division and the Blue Diamond division of the Flintkote Company, the Texas American Sulphur Company and the Pabco Gypsum division of Fibreboard Corporation. As of March 1975, mining operations employed 200 persons in Clark County.

Lithium deposits have been reported in some areas of southern Nevada (Ref. 2-3). Whether or not recoverable reserves exist at the plant site is not known to us. However, U.S. reserves are amply large for current uses. The plant site area is not likely to be exploited until some time after proposed facility decommissioning. Should lithium battery and fusion power requirements for lithium both develop, the resource situation would be unclear, and is currently being debated (Ref. 2-4).

Active mining claims exist in the vicinity, including one with Unit 1. See Section 3.2. BLM has not validated the claim yet, and does not have information on the minerals claimed.

Recreational Use: We are aware of only one significant recreational use of the plant site. (The conditions are severe and uncomfortable.) Recreational off-road vehicle use is occurring and the proposed site is a BLM approved location for large off-road competitions. This use is being discouraged and controlled elsewhere on Federal lands. See Section 3.2.

There may be use by amateur collectors of archaeological and historical artifacts. This activity constitutes an irreversible and uncontrolled exploitation which is being prohibited or discouraged elsewhere.

Conclusions: Outside of urban areas, Clark County has low productivity in land-related activity. The plant sites, Units 1 and 2, in particular, appear to be waste lands, wholly without current or potential agricultural use and little confirmed mineral value.

The alternate site has not been studied with respect to land use aspects.

2.6 GEOLOGY AND HYDROLOGY

Nearly all material in this section has been extracted from the Harry Allen report (Ref. 2-1) in which very much more detailed discussion appears.

Geology

Investigations: The Dry Lake Valley has been investigated several times over the past few years to determine the feasibility of the area for waste disposal, groundwater extraction, and for the Interstate Highway 15 freeway. Many logs of exploration holes were obtained. A program to investigate the Dry Lake Valley for recent faulting and subsidence, and for preliminary foundation conditions for a plant site and water retention ponds was conducted during April through July 1975.

Regional Geology: The proposed plant is located in the central portion of the Basin and Range Physiographic Province. The dominant geologic feature of this province is north-south trending fault block mountains with intermontane alluvial filled valleys. Within the Basin and Range Province, large scale folding, thrust faulting, and strike-slip faulting are present. Rock formations include sedimentary, igneous, and metamorphic rocks ranging in age from Precambrian to Recent.

Internal drainage characterizes much of the northern and central portions of the Basin and Range Province becoming less pronounced in the southern section, although southern Nevada is known to contain cavernous carbonate rock.

The stratified rocks in the vicinity of Dry Lake Valley are largely Ordovician through Permian limestone and dolomite, which rest unconformably on Precambrian basement rocks. The geologic features of southern Nevada suggest that the area has been subjected to several periods of tectonism throughout geologic history.

Local Geology

The geologic features exposed in the vicinity of the Dry Lake Valley are typical of those generally present throughout the Basin and Range Provence.

The formations exposed in the local mountain ranges have been subjected to extensive folding and faulting. The intermontane basins in the vicinity of Dry Lake Valley are structural basins that have been downfaulted. This is reflected by large thicknesses of sediments that fill these basins with alluvial and lacustrine materials consisting of gravels, sands, silts, clays, and evaporites of the Pliocene Muddy Creek Formation. Locally, Quaternary playa deposits occur in the central portions of these basins. The Muddy Creek Formation, present throughout most of the study area unconformably overlies the Paleozoic carbonates. It is poorly to moderately indurated and varies in color from buff, to brown, to red.

A large fault scarp, offsetting the alluvial fans up to 34 m, was investigated about 40 km northwest of Dry Lake in the Sheep Range. This fault was assumed not to be more than a few hundred years old.

After being downdropped, Dry Lake Valley began receiving sediment from the surrounding higher areas with the coarse gravel materials being deposited at the mouths of the drainages and the fine materials being deposited outward into the basin. Being a closed bain, it also received runoff and apparently contained a large saline lake through Pliocene times (The Muddy Creek formation). Sediments are present in the basin to elevations over 610 m. They consist of poorly indurated siltstone, claystone, and fine-grained sandstone. These materials are often gypsiferous and contain layers of crystalline gypsum and halite.

Data indicate that subsidence of the basin occurred prior to deposition of the playa sediments, and of the more recent alluvial fan sediments. The alluvial fan deposits were examined carefully in every wash, gully, cut, and exposure from the mountains to the playa for evidence of cracking, discontinuities, and offset. No cracks, offsets, discontinuities, or other evidence of faulting or subsidence was found within these recent sediments.

Geology of Recommended Site

The proposed site (Units 1 and 2) is located on the alluvial fans at the south end of Dry Lake Valley just up-slope from the north and south ends of the Dry Lake Playa (Figure 2-1). The Arrow Canyon Range borders the site on the west and south. The site has a central area, not planned for use, comprised of the Dry Lake Playa. The Dry Lake Range lies about 3.2 km to the east of the site area.

The southern portion of Dry Lake Valley is mantled by thick coalescing alluvial fans that slope from the mountain toward the Dry Lake Playa. Drill hole data, widely spaced, show the fan materials to interfinger not only with the playa materials but also with the Muddy Creek sediments as well.

Materials underlying the site are composed of coarse gravel from sand to boulder size fragments with some silt and clay to a depth of about 30 m The gravels are principally subrounded to subangular limestone fragments. They are well compacted, weakly cemented, and are permeable. A well cemented caliche layer generally occurs over the area from 1.5 to 3 m below the surface, but is reported to be 25 to 45 cm below the present surface in some portions of the site area (Ref. 2-2). Its thickness is variable, but was found to be up to 1.8 m in some exposures.

The water table was found to occur at about elevation 556 m above MSL, which corresponds to the approximate highest elevation of the clay surface below the deep gravels.

The periphery of the playa is bordered by alluvial fans composed of silty gravel that interfinger with the playa silt and clay. Some gravel lenses protrude considerable distances into the playa materials.

Voids or cracks were encountered in several of the drill holes. Several holes in previous investigations accepted the pump capacities of thick drilling mud with little or no back pressure. The voids are believed to have formed as the result of subsidence and partial solution of the evaporites.

A minimum number of in-situ permeability tests were performed in the playa, Muddy Creek, and the alluvial fan deposits. The tests were performed in accordance with Designation E-18 and E-19 of the U.S. Bureau of Reclamation, Earth Manual. These test results, combined with the drilling fluid loss indicating the presence of voids in some holes, show that materials are sufficiently permeable to allow significant seepage.

Seismology

General: A study was made of the literature pertaining to the seismicity in the vicinity of the Harry Allen Station site. Historical records indicate the areas of earthquake activity and levels of associated damage for this region of the United States; the seismic history is used in determining the design earthquake intensity for this site.

A number of linear features that could be interpreted as faults are present in the Dry Lake Valley. Many of these were investigated both by inspection and trenching. No evidence could be found to indicate offset has occurred since deposition of the most recent alluvial fans. It is concluded that although faulting and extensive subsidence has occurred throughout the site area in the geological past, none has occurred since deposition of the Quaternary gravel and playa deposits.

Earthquake History

Historical records indicate that several significant (intensity V and greater) earthquakes have occurred within 80 km of the site area; however, all but one have centered in the vicinity of Lake Mead and these have occurred since filling of the lake began in 1935 (Figure 2-3).

More than 10,000 earthquakes have occurred at Hoover Dam since it was built. A study of the records of these earthquakes makes it clear that they were related to the increasing weight of the water, since no earthquakes were reported by the few local inhabitants in the 15-yr period prior to the dam's construction.

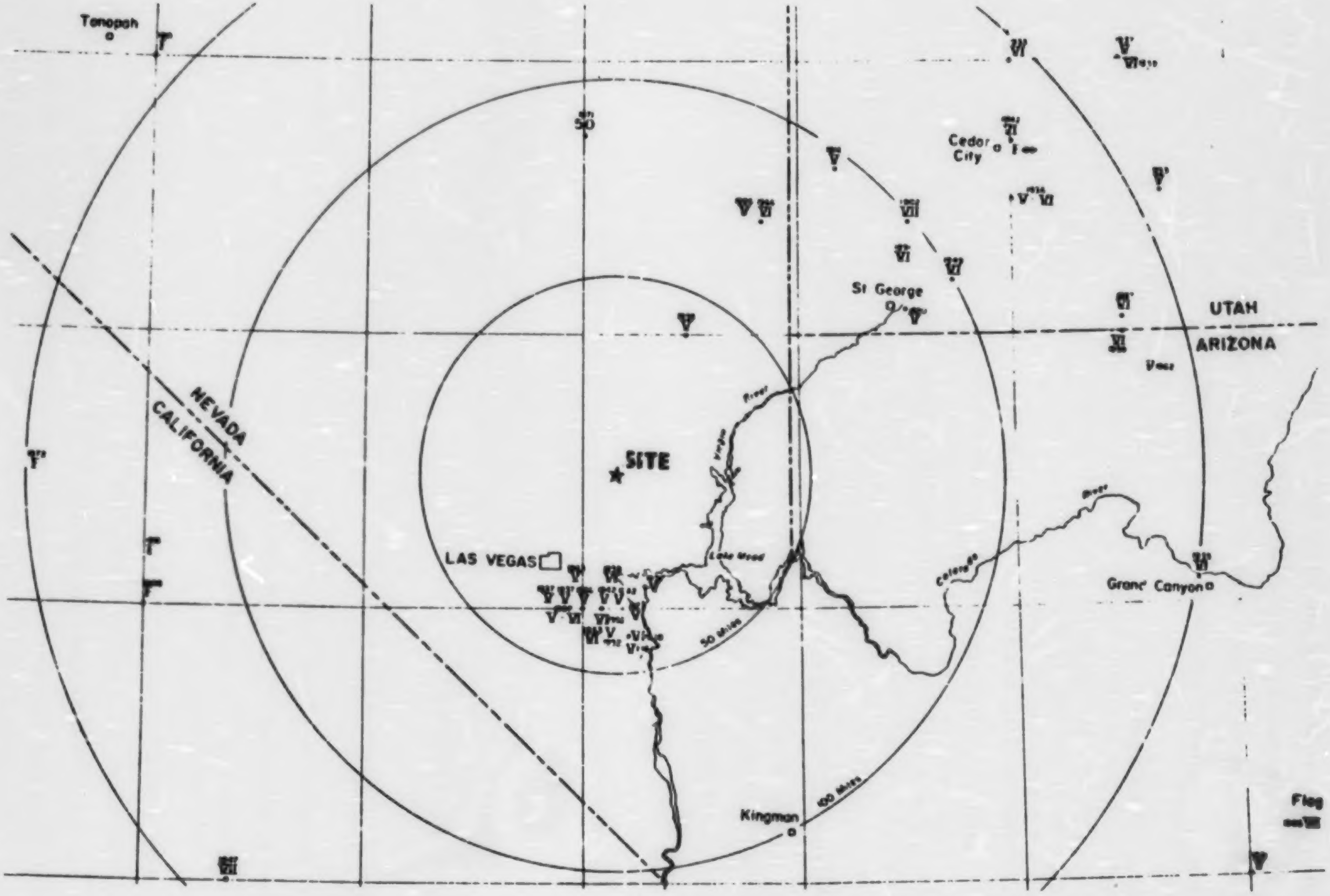
Tonopah
50
Cedar City
St George
UTAH
ARIZONA
NEVADA
CALIFORNIA
SITE
LAS VEGAS
Virgin River
Lake Mead
Colorado River
50 Miles
Grand Canyon
Kingman
100 Miles
Flag

Figure 2-3. Recorded seismic events in Southern Nevada and adjacent portions of California, Utah, and Arizona (Ref. 2-1).

Earthquakes in the vicinity of Lake Mead have also been described. The seismicity associated with Lake Mead has been cited by some workers as a classic example of earthquakes caused by reservoir loading. The epicenters of these earthquakes are distributed around Lake Mead.

- Extensive geologic study of the Lake Mead area was carried out prior to the construction of the dam, and the entire region was found to be broken up by countless minor faults. None was considered to be active prior to the construction of the dam, however, and the subsequent seismic activity is believed to have been caused by reactivation of some of these pre-existing faults.
- ...After several smaller dams were built above Hoover Dam in 1962 to regulate the flow of water, the water level ceased fluctuating as much as it had in previous years and there was a 50% decrease in the number of earthquakes.

Only three significant (intensity V or greater) shocks are listed in Earthquake History as being centered in this area since 1962. The largest shocks occurring in the vicinity of Lake Mead were of intensity VI. The plant site area lies in an area that has experienced intensities of V, but is close to the intensity VI zone.

Based on the available information it seems that the site area has experienced relatively low intensities from earthquakes during historical times, and should expect intensities no greater than VII at the site in the future. Therefore, from standard engineering practices a value of 0.15 g will be used for design.

Foundation Considerations

The upper alluvial material has adequate density and strength to support heavy plant structures on relatively shallow spread foundations. Settlements resulting from application of heavy loads will be small.

Water soluble minerals are found approximately 30 m below the surface in the plant area. The frequency of rainfall and associated runoff is not great enough to cause percolation of the waters to this depth. As a result, leaching of these soluble minerals from the formation would not occur.

If massive and repeated flooding occurred due to construction-associated hydrologic modifications, percolation to the soluble minerals could result. The scarcity of rainfall together with the nature of the grading and construction activity preclude such a result.

Grading and Excavations: The alluvial material in general can be excavated with conventional equipment, even though the material is weakly cemented. Layers of hard caliche are present in the upper several feet of the alluvium stratum. Muddy Creek Formation is not expected to be encountered at the foundation levels of the proposed structures.

Fill Materials: The required quantities of materials for structural fill and backfill purposes can be obtained from onsite sources.

Laboratory Testing: A laboratory test program consisting of: soil type identification, moisture content and dry density, specific gravity, particle size analysis, Atterberg limits, shear strength parameters, constant head permeability tests, and consolidation tests on undisturbed and remolded samples was performed for the Harry Allen plant assessment. Chemical tests were performed to evaluate sulfates, chlorides, and soluble salts present in the subsoil materials. Results appear in Ref. 2-1.

Regional Hydrology

The study area is in typical Mojave Desert environment. The climate of the region features low humidity, little but intense precipitation, and high summer temperature. Potential evapotranspiration is high with a mean annual lake evaporation of about 1.8 m. Mean annual precipitation is about 10 cm. Due to the short, steep gullies and high intensity thunderstorms, runoff results in many flash floods. However, all the streams are ephemeral and flow only during long duration or high intensity storms.

Based upon the little data available concerning the general area, a rough approximation of the 50-yr peak discharge for various size drainage areas has been made. Figure 2.4-8 of Ref. 2-1 was prepared by extrapolation of data for areas 1035 km^2 and larger. For small drainage areas

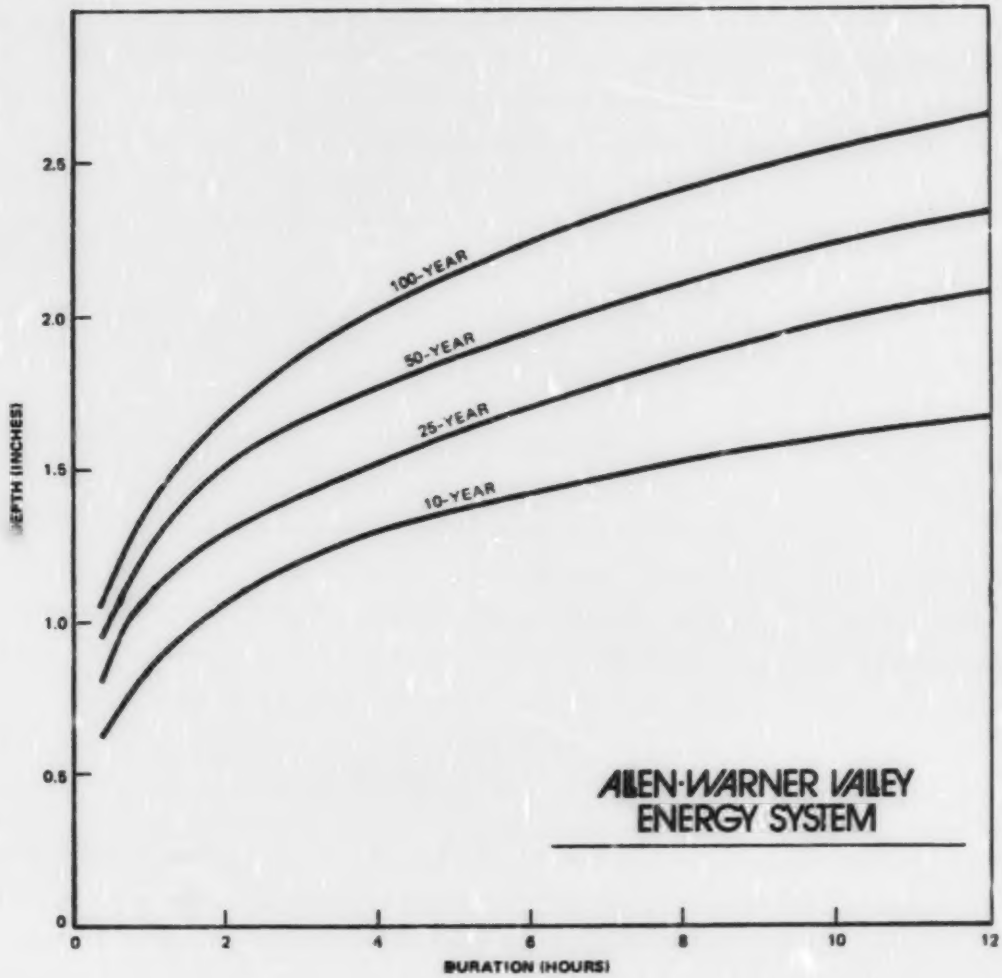

Figure 2-4. Rainfall depth, duration, and frequency curves.

such as are found within the study area, local intense thunderstorms can cause flood peaks greater than those shown in that figure. Onsite drainage systems should use the precipitation data from the depth-duration-frequency curves shown in Figure 2-4.

A discussion of groundwaters appears in Section 2.3.

2.7 CLIMATOLOGY, METEOROLOGY, AND AIR QUALITY

Note: A detailed discussion of these subjects, including site-specific field data, is beyond the scope of this project, and in any event appears in the Harry Allen assessment (Refs. 2-1). Nearly all of the following material was extracted from that reference. We have excluded all meteorological and air quality data relevant only to fossil fuel plants.

Data Collection

Hourly weather observations have been made at the present location of McCarran International Airport, 662 m above MSL since 1948. Hourly records began at Nellis Air Force Base in the early 1940s. The elevation of Nellis AFB is approximately 85 m below the observation point at McCarran Airport.

Weather records at the nuclear test facilities at Yucca Flat began in the early 1960s. However, the elevation of the Yucca Flat climatic station is 1197 m above MSL as compared with 662 m at McCarran Airport.

General Climatological Description

The area within a 96 km radius of Las Vegas consists of broad valleys surrounded by mountain ridges. The larger valleys contain dry lake collection basins at elevations slightly less than 610 m above MSL. High mountains, particularly to the west, have peaks above 3355 m and extended ranges of terrain higher than 2135 m above MSL. Since mountains encircle the various valleys, drainage winds are usually downslope toward the center, or lowest portion of each of the broad valleys. This condition also affects minimum temperatures, which in lower portions of the valleys can be from 8 to 14 C colder than recorded at McCarran Airport on clear, calm nights.

Rainy days average from less than one in June to less than three per month in winter months. Snow rarely falls in the valleys surrounding Las Vegas and it usually melts as it falls, or shortly thereafter. Monthly climatic data of precipitation and temperature are presented in Table 2-14 for McCarran Airport. The arithmetic average of monthly precipitation results in annual total of nearly 10 cm at McCarran Airport.

Tonopah Lows are unique features of weather patterns in Nevada. These low-pressure centers form in Central Nevada after a deep storm center moves from west to east across the Pacific toward the California coast. However, it is almost impossible to follow any low-pressure center moving across California prior to the formation of the new low center in Nevada. While the center is located to the west or northwest of Las Vegas, strong winds from the southerly direction are recorded at McCarran Airport. After the center passes, the airflow shifts to the westerly components.

The intense surface heating during peak summer months creates a semipermanent location of a low-pressure center, which is intensified each day during afternoon hours in the western part of Arizona and the southeastern portion of California. This thermal low pressure center creates an identifiable flow pattern which moves air cyclonically around the center of this low.

The relative absence of major storm systems moving through the Las Vegas area permits a high fraction of hours when calm wind conditions are recorded. The monthly percentages of hours when calm wind conditions exist are recorded at both McCarran Airport and Nellis Air Force Base. Summarized surface wind data appear in Table 2-15 for four local stations identified in Figure 2-5. During winter months, the longer hours of darkness and the creation of a pool of relatively stagnant cool air near the ground helps sustain a higher number of calms.

TABLE 2-14. AVERAGE MONTHLY PRECIPITATION AND TEMPERATURE VALUES AT McCARRAN INTERNATIONAL AIRPORT, LAS VEGAS, NEVADA (1937-1973), (ELEVATION 659 m ABOVE MSL)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Precipitation, Arithmetic Mean, in.*	0.44	0.37	0.41	0.25	0.13	0.08	0.41	0.47	0.35	0.25	0.40	0.36	3.92
Precipitation, 37-Year Median, in.	0.22	0.14	0.22	0.07	0.06	Tr.	0.23	0.25	0.01	0.07	0.22	0.23	
Temp., F, avg. max.**	55.7	61.3	67.8	77.5	87.5	97.2	103.9	101.5	94.8	81.0	65.7	56.7	79.2
Temp., F, avg. min.	32.6	36.9	41.7	50.0	59.0	67.4	75.3	73.3	65.4	53.1	40.8	33.7	52.4
Temp., F, mean	44.2	49.1	54.8	63.8	73.3	82.3	89.6	87.4	80.1	67.1	53.3	45.2	65.8
Temp., F, highest	75	83	91	96	106	115	116	113	107	99	85	72	116
Temp., F, lowest	8	19	23	32	40	51	62	56	46	26	27	15	8

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*1 in. = 2.54 cm.

**0.555 (^{o}F-32) = ^{o}C.

TABLE 2-15. SUMMARY OF SURFACE WINDS*

Speed Categories Knots**		Base Station, %	Pump House %	California Wash, %	Powerline Bend %
1	0-3	20.7	50.8	42.3	52.7
2	4-6	33.0	17.5	23.8	19.8
3	7-10	31.5	16.7	14.7	14.6
4	11-16	10.8	9.1	10.3	8.0
5	17-20	3.2	4.6	6.2	3.3
6	_ 21	0.8	1.2	2.6	1.4

*Data by Desert Research Institute, University of Nevada, as reported in Ref. 2-1.

**1 knot = 1.852 km/hr.

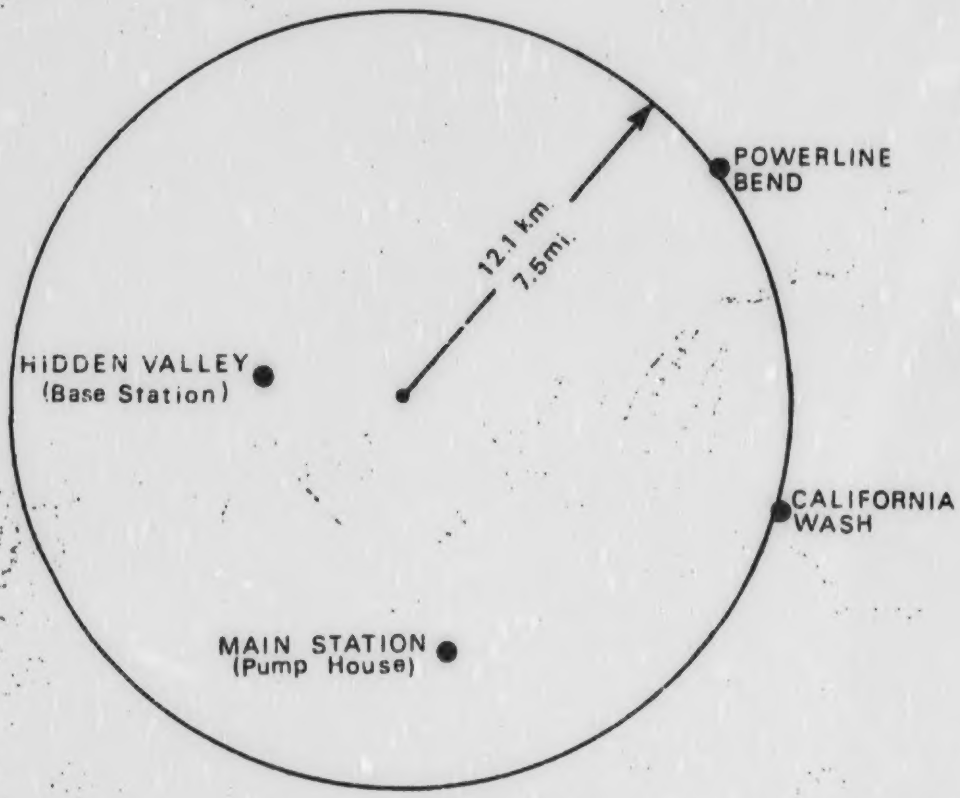
12.1 km
7.5mi.
POWERLINE BEND
HIDDEN VALLEY (Base Station)
CALIFORNIA WASH
MAIN STATION (Pump House)

Figure 2-5. Location of meteorological stations surrounding the Dry Lake site (cf. Table 2-15).

A high frequency of calms can be expected in any dry lake area for wind measurements made near the ground. Such calm conditions would permit a high thermal rise to any plume emanating from a pollutant source. In many instances, material in the plume would move upward and away from the source within synoptic airflow that nearly always prevails above the surface stable layer.

On the other hand, an examination of 1973 wind measurements at McCarran Airport indicates that there were 520 hours when winds were 33 km/hr or greater. There are two important direction ranges for strong winds. The highest frequency occurs in the direction range 200 through 230 deg with a secondary peak extending from 320 through 340 deg.

Stability Climatology

In the Las Vegas area, there is a daily cycle of stability that repeats itself almost every day in the year. There is a layer of stable air near the ground during night and early forenoon hours, followed by neutral or unstable conditions in the afternoon and early evening hours. A layer of stable air near the ground occurs at 0400 PST on over 84% of all days per year. On 10% of the mornings, there is no inversion. These findings are based on a 5-year analysis of vertical temperature profile data measured by radiosonde techniques at the McCarran Airport.

The same 5-year summary covering afternoon temperature profiles at McCarran Airport shows only 10 instances where there were surface-based inversions below 500 m. This would be a frequency level of only twice per year.

It is evident that the early morning surface-based inversions are eliminated almost every day throughout the year. The corresponding changes in stability within each 24-hour period would move from stable to neutral and/or unstable, then back to stable. There would be almost no cumulative pollution build-up into subsequent days. The depth of the stable layer may be relatively shallow at the proposed site. Detailed vertical temperature soundings will be needed to establish a frequency pattern. Care must be taken when the foregoing is viewed with respect to pollutant dispersion from the proposed site since it is to be some 48 km from McCarran Airport in Las Vegas and is in vastly different topography.

Meteorology

Data collected on a routine basis consists of continuous surface meteorological and air quality data, upper air winds from the daily pibal observations, and temperature sounding data taken by aircraft every third day. The evaluation and analysis of these data is made with the purpose of establishing normal or background characteristics for the meteorological and air quality description of the siting area.

Surface Meteorology

Wind speed and direction plus temperature data have been taken at four sites. Humidity, net radiation, and precipitation data have been taken at two sites: Hidden Valley (Base Station) from August through November 1974 and Main Station (Pump House) from December 1974 through June 1975.

The temperature data taken at the various sites shows the anticipated march of temperature throughout the year. The summer months are extremely hot with most days exceeding 40 C. During the fall months the temperature gradually decreases so that during the winter the average temperature is fairly cool, around 20 C.

Radiation

The measurement of net radiation has been made at the sampling sites described above, from August 1974 through June 1975. These data are of interest in determining cloud cover and the total net amount of the incoming minus outgoing radiation. The records show that on most days, the maximum amount possible of solar radiation has been received at the air quality measurement site due to the general absence of clouds. On very few days, the records show low values of net radiation associated with low clouds and/or continuous precipitation.

Relative Humidity

Relative humidity (RH) in southern Nevada is normally low. Measurements at the Base Station and Pump House stations (Figure 2-5) show that RH > 50% only 16.4% of the time. Summer RH rarely exceeds 35 to 40%. In fall through spring, RH > 65% only 8 to 10% of the time. Occasional visibility limiting ground fogs persist for several days.

Air Quality and Visibility

Air quality and visibility measurements were performed by Nevada Power's consultants from August 1974 through June 1975 to determine the background levels of various pollutants in the area of the Harry Allen Station site (Ref.2-1). The following contaminants were monitored continuously.

- Sulfur Dioxide (SO_2)
- Oxides of Nitrogen (NO_x)
- Nitrogen Oxide (NO)
- Nitrogen Dioxide (NO_2)
- Ozone (O_3)
- Total Hydrocarbons (THC)
- Methane (CH_4)
- Carbon Monoxide (CO)
- Visibility

Manual sampling for total suspended particulates (TSP), SO_2, NO_2, and NO was also carried out. The manual sampling for TSP was the only method acceptable by EPA for this pollutant. The gaseous contaminants, SO_2, NO_2, and NO were also manually sampled to obtain 24-hr integrated samples to confirm the continuous monitoring data. The data are summarized in Table 2-16. Dust storms caused by strong winds normally result in reduced visibility and high concentrations of suspended particulates. However, the visual range is normally between 80 and 130 km.

Baseline air quality for the proposed site was found to be at normal background levels, representative of the undisturbed as well as unpopulated southwest desert, except for the total hydrocarbons, methane and carbon

TABLE 2-16. BACKGROUND CONCENTRATIONS OF VARIOUS CONTAMINANTS IN THE AREA OF THE PROPOSED SITE

Contaminants	Mean	Peak 24-hr Average	Peak 3-hr Average
Particulates	35 μg m^{-3}	405 μg m^{-3}	—
SO_2	< 5 ppb	< 5 ppb	< 20 ppb
NO	< 10 ppb	17 ppb	—
NO_2	< 6 ppb	32 ppb	—
O_3	15-20 ppb	—	—
THC	1.7 ppm	—	7.4 ppm
CH_4	1.5 ppm	—	7.1 ppm
CO	1.2 ppm	—	3.4 ppm

monoxide. Measured concentrations of total hydrocarbons, methane and carbon monoxide are all well above normal background levels. The reason for these higher concentrations is largely uncertain. They are not attributable to traffic on Interstate 15, the Union Pacific Railroad, the Reid-Gardner Station or Las Vegas urban plume, because there are no corresponding higher levels of oxides of nitrogen and ozone. Their relation to industrial sources in East Las Vegas is not known.

2.8 AMBIENT NOISE

Ambient noise measurements were performed at five stations by Nevada Power consultants (Ref. 2-1) during the week of April 28, 1975. The data, collected for one week only, were considered adequate to provide a description of the ambient noise environment at the proposed site and at the nearest residence. The latter is on U.S. Highway 93 at the south edge of Unit 1 of the proposed solar electric site.

Non-related intrusions (military jet aircraft flyover, and highway traffic) are subject to administrative and socio-economic changes beyond the control of project proposers. Noise levels due to these intrusions therefore, cannot be projected quantitatively. Nuclear test shots at nearby Yucca Flats are a seismic but not an appreciable noise source.

Statistical analyses of the A-weighted noise levels provides a method of quantifying the outdoor noise levels. These analyses can provide the cumulative noise level, that is an estimate of the level that is exceeded for a percentage of the time. The cumulative levels presented are L_1, L_{10}, L_{50}, L_{90} (the level exceeded 1, 10, 50 and 90%, respectively). The ambient noise is the residual level when no identifiable noise sources are present. The A-weighted noise level exceeded 90% of the time (L_{90}) is used to describe the ambient noise level.

The U.S. Environmental Protection Agency has chosen the A-weighted energy equivalent average level, L_{eq} (equivalent sound level), and the A-weighted equivalent day-night level, L_{dn}, as adequate reporting systems for identifying and quantifying the environmental noise. The L_{dn} is the 24-hr equivalent sound level with a 10 dB nighttime penalty.

The A-weighted cumulative distribution levels for each of the five locations are shown in Table 2-17. These levels are high for desert environments due to the frequent flyover of military jets taking off and landing at Nellis Air Force Base and the traffic noise from Interstate Highway 15 and U.S. Highway 93. Noise levels from jet aircraft flyovers in excess of 60 dBA were recorded. Noise due to 60-cycle hum from existing 230 and 500 kV transmission lines was not identified, and is apparently overwhelmed by traffic noise on highways sharing the transmission line corridor. The noise environment on the proposed site can be described as typical of rural environment with frequent intrusions due to military jet aircraft flyovers.

2.9 ECOLOGICAL SETTING

by W. Glen Bradley

The ecological evaluation of any area requires not only detailed inventory and analysis of the area itself but a general knowledge of how this area compares with and relates to the particular ecological region or unit of which it is a part. Of particular importance is how typical or characteristic is the area being evaluated. The portion of the Harry Allen Study Area corresponding to proposed and alternate hypothetical solar-electric plant sites are compared with southern Nevada specifically and with the northern Mojave

TABLE 2-17. AMBIENT NOISE LEVELS* AT MONITORING LOCATIONS SURROUNDING UNIT 1

Sta.	Geographic and Environmental Description	Major Noise Sources	Statistical Sound Levels, dBA**					
			L_1	L_{10}	L_{50}	L_{90}	Leq	L_{dn}
1	Open desert. Nearest residence 3.2 km. West edge of Unit 1 on dirt road 0.8 km from U.S. Hwy. 93	Military jet aircraft flyover	53	39	30	26	46	51
2	Highway intersection on North edge of U.S. 93 right of way 90 m west of IS 15	Traffic; military jet aircraft flyover.	68	62	48	36	--	--
3	Southwest edge of Unit 1 Nearest residence 0.8 km away. On edge of U. S. 93 right of way	Traffic; military jet aircraft flyover	71	52	37	26	58	63
4	Open desert inside Unit 1 Nearest residence 4 km away. Next to dirt road remote from traffic	Military jet aircraft flyover.	58	39	30	24	49	51
5	30 m west of West Frontage Road along Hw. 19 ~1.7 mi. from U.S. Hwy. 93 almost under 500 kV transmission line	Traffic; military jet aircraft flyover.	67	58	48	37	56	63

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*For explanations of statistical noise levels, refer to document, "A Brief Explanation of 'A-weighting' and 'Statistical Analyses of Noise Levels'," adapted from Community Noise, PB-207-124, EPA, Washington, D.C., 1971, and U.S. Environmental Protection Agency, "Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare," 550/9-74-004, March 1974.

**dB ré 20 micropascals.

Desert generally. Data for regional analysis were obtained from the literature especially as summarized by Allred et al. (Ref. 2-5), Bradley and Deacon (Ref. 2-6), and Austin and Bradley (Ref. 2-7). Judgments on the potential occurrence of biota on the Study Area were based on the above cited works, our extensive personal experience in southern Nevada and observations made to date on the Study Area.

Description of Region

Southern Nevada including Clark County and the lower elevations of southern Lincoln and southeastern Nye counties are part of the northern Mojave Desert. The Mojave Desert is transitional between the cold Great Basin Desert to the north and the more southern, hot Sonoran Desert (Bradley, Ref. 2-8). The Mojave Desert includes those portions of Nevada and adjacent desert areas of California which intergrade with the lower elevational Sonoran Desert. Some authorities include the southwestern area of Utah which occupies the Virgin River drainage and portions of Arizona adjacent to Nevada.

The Mojave Desert region represents the southern part of the Basin and Range Physiographic Province. The Basin and Range Province is characterized by numerous north-south oriented mountain ranges accompanied by valleys without external drainage. Most of these ranges, found within the Mojave Desert, are below 3000 m elevation with much of the valley floor above 610 m. Commonly as a result of internal drainage, well-developed playas occupy the lowest portions of the valley floor. Desert vegetation is well-developed at elevations up to 1830 m and on some of the smaller mountain ranges, at higher elevations. Soils are commonly of a gray desert type with proportions of rock, gravel, sand, silt and clay dependent upon location along the elevational gradient. For example, the soils of alluvial fans (bajada) are high in rock, gravel and sand, while the lower valleys are largely made up of a sandy, silty loam. Silts and clays dominate playas while localized sand dune areas may occupy the leeward side of valleys.

The Mojave Desert is characterized by hot summers. Winters are relatively cold with nightly temperatures commonly below freezing.

Precipitation patterns are erratic from year to year, usually varying between 5 and 25 cm per year for all but the highest elevations. Both temperature and yearly precipitation fluctuate greatly from year to year (Bradley and Deacon, (Ref. 2-6). Snow is common at 1220 m and higher during late fall and winter.

In southern Nevada several large mountain ranges extend to elevations above 2440 m and have well-developed coniferous forests which are not characteristic of most mountain ranges in the Mojave Desert. However, much of the area is occupied by desert mountain ranges and associated valleys. The region in the vicinity of Las Vegas has been studied in some detail and numerous ecological relationships have been documented.

Biotic Associations of Southern Nevada

Natural groupings of populations of plants and animals occupying a given area are classified ecologically as biotic communities. Responding to environmental gradients, they occur as vegetation zones which are especially steep and obvious in areas with topographical diversity, as in southern Nevada. In desert regions the environmental gradient is largely influenced by precipitation and temperature patterns which greatly modify water availability, which is the major regulatory factor in desert ecosystems. In turn, animals which depend upon vegetation for food, shelter and other requirements for life, show similar gradients in their distribution. Natural groupings of biota are recognized as communities because of the overlap of tolerances of a large proportion of the biota to various environmental factors. Because of nonoverlap in tolerances to certain environmental phenomena, both within and between community variation exists to a lesser or greater degree.

The major terrestrial biotic communities of southern Nevada have been generally described (Bradley and Deacon, Ref. 2-6). The major community found at lower elevations occurs throughout the proposed solar-electric plant site.

Cresote Bush Community: The Creosote Bush Community is the most extensive and widespread community of the southern North American deserts (Sonoran, Chihuahuan, and Mojave). In southern Nevada it is well-developed throughout the lower elevations to 1280 m and higher on south facing slopes and on small isolated mountain ranges.

The topography ranges from valley floors to lower bajadas and in some areas includes very rocky and rugged terrain. The general topography is dissected throughout by desert washes and interrupted by small hills and low mountain ranges.

Typical soils are gray, rocky alluvium without soil horizons, slightly alkaline and with a salt content usually < 0.5%. Often there is a hard subsurface layer of caliche. Many areas are overlain with desert pavement.

Plants: Throughout this community the vegetation is typified by Creosote Bush and Burro Bush as the dominants. These usually occur together but occasionally occur in almost pure stands. Yuccas, primarily Mojave Yucca are common associated plants especially on bajadas. Other shrubs usually associated with this community are Krameria parvifolia, Parosela spp., Atriplex supp., Ephedra nevadensis, Salvia spp., Encelia farinosa, Thamnosma montana, Mendora spinescens, Psilostrophe cooperi, Lycium spp., and Eriogonum spp. In some areas cacti, especially prickly pears and chollas (Opuntia spp.), Barrel Cactus and Hedgehog Cactus are common.

Large numbers of species compose the herbaceous vegetation, the most common of which are composites, mustards and legumes. These vary considerably from year to year in density, size and species richness being most prominent in years of high precipitation when they cover the desert floor.

Reptiles and Amphibians: Reptiles, especially lizards, are widespread, abundant, and commonly observed in this community. The more abundant lizards include Desert Crested Lizard, Zebra-tailed Lizard, Side-blotched Lizard, Desert Horned Lizard, and Western Whiptail. The more common snakes include Common Whipsnake, Gopher Snake and Sidewinder. The Desert Tortoise is frequently observed in this community. Occasional amphibians are found in this community but are considered to belong to adjacent more mesic communities.

Birds: Of the birds occurring here, very few are common. Most species recorded belong to adjacent riparian communities and are not part of the Creosote Bush community avifauna proper. Most species of this community reach their greatest abundance on the bajadas in association with yuccas. The more abundant species throughout the community include Horned Lark, House Finch, Black-Throated Sparrow and Sage Sparrow. Species commonly associated with yuccas include Ladder-backed Woodpecker, Ash-Throated Flycatcher, Cactus Wren, Loggerhead Shrike and Scott's Oriole. Occasional individuals of many species will use this community to forage during migration. Species from higher elevations may occur during winter with considerable year to year differences in the species present and in their abundance.

Mammals: Relatively large populations of several mammal species are found in the Cresote Bush community. Common bats which utilize this community include California Mouse-Eared Bat, Western Pipistrelle, Big Brown Bat, Pallid Bat, Lump-Nosed Bat and Mexican Free-Tailed Bat. Common and characteristic rodents include Antelope Ground Squirrel, Round-Tailed Ground Squirrel, Merriam's Kangaroo Rat, Long-Tailed Pocket Mouse, Little Pocket Mouse, Desert Wood Rat, Canyon Mouse and Cactus Mouse. The Black-Tailed Jackrabbit is widespread and common. The only common mammalian predators are the Coyote, Badger and foxes. Larger herbivores are rarely seen.

Adaptations of Desert Biota

The following discussion is a generalized account of the major strategies utilized by biota for desert existence. Much of the literature on desert adaptation has been recently summarized in volumes edited by Brown (Ref. 2-9).

An organism's ability to exist in the desert is determined by its ability to maintain favorable water balance and suitable temperature range as all vital processes occur in an aqueous medium within a temperature range specific for any particular organism. Extreme temperatures coupled with high evaporation rates and scarcity of water are responsible directly or indirectly for the adaptations exhibited by desert organisms. Both distribution and abundance of desert biota depends largely on behavioral and/or physiological adaptations which allow organisms to achieve homeostasis.

Many desert shrubs exhibit a uniform widely spaced dispersion pattern, thus limiting extreme competition for water. In Creosote Bush, for example, root secretions are produced which inhibit germination of other Creosote Bushes in the near vicinity. Certain desert plants display root systems that intercept different water sources in the soil profile. Shrubs and trees such as Desert Willow and Mesquite are found along desert washes. Here, elongated root systems, sometimes extending down to 12 m, tap the underground water sources. Succulents such as yuccas and cacti have shallow root systems that extend just below the surface of the ground. This enables these plants to utilize low precipitation and near surface runoff.

Succulents are noted for their capacity to store water. This is an apparent adaptation to ensure sufficient water necessary for metabolic processes during periods in which a dependable water supply is not available. Also, certain leaf characteristics such as reduced size, thick cuticle, leaf hairs and reduced or sunken stomata have been considered as important morphological modifications to retard water loss.

Desert vegetation is dominated by seemingly lifeless shrubs which display active growth for brief periods. This dormant condition is characterized by extreme dehydration and low metabolic activity. Dormancy accompanied by a tolerance for dehydration is highly developed and is the major adaptation which enables perennial plants to exist in the desert.

The ability of seeds to survive environmental extremes is well known. As seeds, the dormant condition may be extended over several years. When suitable conditions appear, germination, growth and corresponding metabolic activities occur. Desert annuals, known as ephemerals, develop from seeds during those brief periods when the desert environment is altered by precipitation. During these favorable periods, as metabolic activities increase, vegetative growth is kept at a minimum while flowering and seed production is emphasized. In these dwarf plants the complete life cycle may be completed in as short a period as three weeks. Chances for survival of the individual plant is enhanced by very precise conditions for germination.

Behavior, especially activity patterns which limit activity to the most favorable daily and seasonal periods is the major adaptation employed by desert animals (Bradley and Yousef, Ref. 2-10). This is most clearly shown as daily activity patterns such as diurnal, nocturnal, crepuscular and daily dormancy or seasonal patterns such as migrations and hibernation (seasonal dormancy). It is obvious that the major behavioral strategy involved in these activity patterns is the avoidance of environmental extremes.

Dormancy, which is a major adaptation in desert plants, is also a major strategy used by many vertebrate and invertebrate groups. This is a special case of physiological specialization accompanied by behavioral avoidance. Each terrestrial vertebrate group, therefore, employs a particular combination of adaptive physiological and behavioral strategies which determines their distribution and survival.

Amphibians have a limited distribution in deserts with the more aquatic forms restricted to riparian habitats. Terrestrial forms, particularly Scaphiopus hammondi (Hammond's Spadefoot Toad) extends into more arid regions, utilizing dormancy as the key to survival. Located in underground burrows, they undergo gradual dehydration over long periods of time. During these periods urine formation largely ceases and extreme desiccation is possible. Adults recover water lost during dehydration by absorption through the skin during and after periods of precipitation.

Activity and breeding is restricted to areas around temporary pools after summer rains.

Reptiles are poikilothermic, with body temperature approximating air temperature. Necessarily, these organisms behaviorally alter their microhabitats and thus regulate their body temperature. Withdrawal into protected sites, both daily and seasonal, results in hibernation or aestivation which increases survivability. Water is commonly ingested in the form of succulent food although desert reptiles will utilize free water when available. The cornified layer of scales retards water loss by evaporation. Nitrogenous waste in the form of uric acid precipitate permits removal of body wastes with minimal water loss. Reproductive efficiency is greatly facilitated by the land egg with a thick shell which retards water loss.

Birds and mammals are homeothermic and regulate their body temperature at relatively constant high levels, at least when active. Under temperature extremes the common methods used to maintain body temperature are changes in insulation, evaporative cooling or shivering and increasing metabolic rate. Behaviorally, these animals utilize avoidance; birds retreating to shady areas and most mammals to cool burrows.

In birds, nitrogenous wastes are largely removed from the body as uric acid precipitates. However, due to high breathing rates associated with flight, evaporative water loss is great. It is doubtful if any bird can survive without free water or succulent food. This accounts for depauperate breeding avifaunas in low desert. Because of high mobility the major adaptive strategy of birds include daily movements to watering sources and/or seasonal migrations.

Mammals exhibit a wide variety of adaptive responses including dormancy, hyperthermia and production of concentrated urine. Certain ground squirrels aestivate during the summer which is the period of greatest scarcity of green vegetation. Other rodents, particularly pocket mice, hibernate in the winter when seeds are scarcest.

A highly efficient kidney which produces concentrated urine is found in antelope ground squirrels, pocket mice, kangaroo rats and certain bats. Some of these animals such as Merriam's Kangaroo Rat and the Pallid Bat are known to survive entirely without free water. Water conservation is further enhanced by eating succulent foods and avoiding conditions of high temperature and low water vapor pressure. The strategy of avoidance is the most used as evidenced by the large number of nocturnal, burrowing animals.

A few mammals, such as antelope ground squirrels and desert sheep, are diurnal and therefore forego a certain degree of avoidance. The antelope squirrel utilizes metabolic water, succulent food and any available free water. In addition, it concentrates urine and allows for hyperthermia or heat loading. As body temperatures build up during the day, the heat load is lost to the environment by movements into the shade or underground burrows. By utilizing the many burrows scattered throughout the home range as temporary shelters for dissipating heat, the animal can remain active during the less extreme part of the day without major loss of water in thermoregulation.

The mechanisms which enable large mammals such as desert sheep to survive in the desert are partially unknown. Domestic sheep have a concentrated urine, and preliminary indications reveal that Desert Bighorms possess similar characteristics. Another large desert mammal, the Camel, has concentrated urine, and a tolerance for extreme dehydration and hyperthermia. These specializations are to be looked for in the large American desert mammals. Desert sheep occupy shady sites during periods of extreme heat and travel long distances to water. At other times, they appear to be able to go for as yet undetermined periods utilizing water from succulent foods. This would suggest some tolerance for dehydration but would indicate that these mammals restrict their range during warm seasons to the proximity of free water.

Trophic Relationships

Detailed trophic relationships have not been documented for Mojave Desert biotic communities. However, selected species have been studied in the Las Vegas area which allow some generalizations (Bradley and Deacon, Ref. 2-6; Bradley, Ref. 2-11; Bradley and Deacon, Ref. 2-12; Bradley and Mauer, Ref. 2-13; Bradley, unpublished data)

Generalized data on the food habits of vertebrates are included in Subsection 1. A brief statement concerning trophic relationships is provided below.

As in all ecosystems, the primary producers (green plants) form the food base for animal populations. Herbivores include Desert Tortoise, Desert Iguana, Chuckwalla, Black-Tailed Jackrabbit, Audubon's Cottontail and Desert Bighorn Sheep. Of these, the Jackrabbit and Cottontail provide the major browsing and grazing pressure on the desert ecosystem. Seed eaters, especially rodents and some birds, are of potential importance in the cropping of the rather abundant seed reserves found in deserts. For successful reproduction most rodent species, however, are largely dependent on spring production of annual vegetation which is consumed as green vegetation. This provides the added water supplement needed for pregnancy and lactation and possibly estrogenic substances needed for the development of reproductive condition. Both herbivore and seed eating components are considered primary consumers.

All of the other vertebrate species which rely chiefly on arthropod or vertebrates for food are classified as predators and thus secondary or tertiary consumers. In general, lizards feed on other lizards and arthropods as a food source, whereas snakes feed chiefly on bird and lizard eggs, lizards and small rodents. Considerable evidence indicates that the abundant and diversified rodent fauna is the main food source for the larger snakes, predatory birds and such carnivores as Coyote, foxes and Badger.

A realistic model of trophic relationships involves rather complex food webs with many vertebrate species being opportunistic and relying on those appropriate food sources within their general food preference which are locally or seasonally available.

Community Succession

Disturbance of desert communities by such activities as fire, removal of vegetative cover and other activities associated with community alteration by man can produce distinct changes, termed community succession. Desert ecosystems are fragile, easily disturbed by human activities and are slow to recover due to slow growth responses under the direct influence of low water availability and poor soil development.

Vegetative succession is varied but usually relatively simple. In areas far removed from human development with essentially natural vegetation, succession may involve seral stages of annual vegetation usually associated with disturbed areas such as desert washes. However, since nonnative species such as Russian Thistle, Red Brome and Cranesbill are commonly available, succession is usually altered.

The first species to invade are usually Russian Thistle and Red Brome. Following this, various annuals, especially types which are most common in washes, invade. These include annual Eriogonum spp., Bromus spp., Cranesbill and various mustards. Following this, such perennials as Baileya, Hymenoclea, Gutierrezia and Sphaeralcea become established. These three elements combine to produce seral stages of long duration, probably in excess of 50 years. The exact details of return to the climax community are unknown and would vary, depending upon location, however, many areas of Mojave Desert have not recovered to climax state in approximately 100 years (1961). Vertebrate faunas of seral stages would be similar to those found in climax communities. Animal populations would fluctuate, however, during succession and in some species, densities would be higher during seral stages of succession.

Biotic Associations of the Solar Electric Station Study Area

The physiography of the solar power station study area is typical of low desert in southern Nevada. The valley floor slopes up into two low but rugged mountain ranges (Dry Lake Range and Arrow Canyon Range), and to the east into the higher Las Vegas Range. The entire area is dissected by numerous desert washes which drain the surrounding ranges. In some areas the bajada is interrupted by low rocky knolls. On the valley floor there is a relatively large dry lake.

The proposed hypothetical solar-electrical plant site is divided into two sections; one to the southwest and the other to the northeast of Dry Lake playa. The eastern boundary of both sections is adjacent to the Union Pacific railroad tracks, whereas the eastern boundary is adjacent to the Arrow Canyon Range. These two sections are similar in elevation, ranging from approximately 610 to 720 m. The alternate site is continuous with the northeastern portion of the proposed site, but extends further north. Elevations of the alternate site vary between 610 to 781 m with the exception of a small mountainous area of 3 km^2 located in the north-central portion. This area, which rises to above 854 m, has uneven topography and probably would not be utilized for solar-electric units.

The general description given for the Creosote Bush Community in southern Nevada applies equally well to both sites. Small areas of Desert Riparian Community are found along the washes. The vegetation along these washes does include some species characteristic of washes, with individual plants being larger and more numerous. Animals inhabiting these areas are the same as those found in Creosote Bush Communities, although relative abundance may differ.

Vegetation

All areas of the proposed and alternate solar-electric sites are composed of Creosote Bush Community with Burrobush and Creosote Bush as codominants. Due to the much smaller size in area of the proposed solar-electric sites, exact numeration of species occurring cannot be obtained from Appendix B, Subsection 1.1, (Ref.2-1), or the 1976 unpublished Appendix B Update and Appendix I. It is estimated, however, that approximately 212 species (64%) of a potential 329 species occur on the proposed and alternate solar-electric sites.

Based upon reanalysis of 8 plant sampling stations located on the southern portion of the proposed site, mean perennial plant cover was 2.3% with a range of 1.5 to 4.0%. A total of 28 perennial and 39 annual species occurred at these sampling stations.

Other than codominants, important perennial species ranked according to their relative importance were Little-leaved Ratany, Nevada Mormon Tea, Desert Mallow, Cooper Lycium, Spiny Mendora, and Cheese-bush.

Seven plant sampling stations located on the northern portion of the proposed site and the expanded alternative site were reanalyzed. Plant cover was more sparse and fewer plant species were found in these areas than on the southern section of the proposed site. Mean perennial plant cover was 1.7%, ranging from 0.5 to 3.1%. Only 12 perennial species were found on the sample stations. No samples of annual species were available for analysis for these areas. The relative ranking of subordinate species was somewhat different with Russian Thistle, Galleta, and Winterfat being important plant species.

Vertebrates

The distribution of vertebrates found on the two proposed and alternate solar-electric sites were analyzed based upon data found in Appendix B, Subsections 1.2 through 1.5, and Appendix B Update, Appendix I (loc.cit).

Amphibians: No amphibians were found on any site, although one species, Hammond's Spadefoot Toad, was found on Dry Lake playa adjacent to the proposed and alternate sites.

Reptiles: Fifteen species of reptiles were found on the proposed and alternate sites out of 29 which potentially occur in lower desert communities. Of these one is a tortoise, eight are lizards, and six are snakes.

The Desert Tortoise is relatively common throughout the relatively flat portions of the Study Area but is apparently absent on rock knolls slopes and ridges of the surrounding mountainous area.

Two lizards, the Side-Blotched Lizard and the Western Whiptail, are abundant and widespread throughout the sites. Zebra-Tailed Lizards are also widespread and common, especially along the courses of washes. In the lower and more sandy portions of the area, especially on the northern proposed and alternate solar-electric sites Desert Horned Lizards are common. The remaining species of lizards (Desert Crested Lizard, Chuckwalla, Collared Lizard and Leopard Lizard) are represented by 1 to 3 sightings each and are to be considered uncommon on the sites.

The two most common species of snakes on the sites are the Common Whipsnake and the Gopher Snake, each represented by several sightings. These two species are considered the characteristic species of lower desert areas. The remaining species (Common King Snake, Long-Nosed Snake, Western Patch-Nosed Snake and Speckled Rattlesnake) are represented by 1 to 2 records each and are considered uncommon to rare on the sites.

All species of reptiles encountered to date are those that are to be expected in the lower desert of southern Nevada. The relative abundance and apparent densities of lizards are comparable to those of other similar low desert areas of southern Nevada. Likewise, the two most common snakes are also the most abundant in other low desert areas of the Mojave Desert. It is surprising that the relatively common Sidewinder has not been recorded on the sites to date. The Desert Tortoise is on the Nevada Threatened Species List. Although its actual density on the Study Area is unknown, the frequency of sightings indicate a relatively dense population. In our opinion, however, this population is comparable in density to others in southern Nevada; the species being rare only near population centers and immediately adjacent to highways.

Birds: A total of 70 species (of a potentially occurring 90 species) were found on the station study area. Most of these probably occur on the proposed and alternate solar-electric sites. Of these 70 species, 23 were permanent residents, 16 winter residents, 8 summer residents, 22 transients, and 2 visitants. Permanent residents include the following: Red-Tailed Hawk, Prarie Falcon, Sparrow Hawk, Gambel's Quail, Killdeer, Roadrunner, Burrowing Owl, Ladder-Backed Woodpecker, Say's Phoebe, Horned Lark, Verdin, Bewick's Wren, Cactus Wren, Rock Wren, Mockingbird, LeConte's Thrasher, Black-Tailed Gnatcatcher, Loggerhead Shrike, Red-Winged Blackbird, Brown-Headed Cowbird, House Finch and Phainopepla. Nine species (see p. 31, Appendix B Update) are known to breed on the station study area.

The solar-electric sites are relatively impoverished in diversity and numbers of birds of prey, with the most important commonly observed species being the Red-Tailed Hawk. The only game species are Gambel's Quail and Mourning Dove, both of which occur at low densities. The Mourning Dove, however, is an uncommon nesting species on the station study area. Other birds make up the majority of avifauna on the area. In general, sparrows were the most numerous group throughout the year, with Sage Sparrow dominant in winter and Black-Throated Sparrow in summer. Population densities and biomass were greatest during early winter, decreased into late winter, increased in spring migration, and declined to lowest levels in late summer. Species composition of birds was as expected for similar areas in the northern Mojave Desert with low densities and biomass which is characteristic of desert communities.

Mammals: A total of 24 out of a possible 37 species of mammals have been recorded on the Harry Allen Study Area. Most probably occur on the solar-electric sites. All species recorded are expected to occur in similar habitat in the northern Mojave Desert. One species, the Spotted Skunk, is quite uncommon away from riparian areas adjacent to water. Bats are often seen in the evening and morning throughout the Study Area. The Black-Tailed Jackrabbit is common throughout the Study Area; the Audubon's Cottontail is common in the vicinity of the Dry Lake. Coyotes are the most common predator on the Study Area being distributed throughout. The Kit Fox has been seen occasionally in the lower areas of the Study Area especially near the Dry Lake. The Bobcat was observed once crossing a highway. Desert sheep commonly occur throughout much of the Arrow Canyon Range but seldom utilize the area of the proposed and alternative solar-electric sites.

Rodents comprise the largest group of mammals using the proposed and alternate solar-electric sites. Common to abundant species include Merriam's Kangaroo Rat, Long-Tailed Pocket Mouse, Little Pocket Mouse, Antelope Ground Squirrel, and Desert Deer Mouse. All rodent species found were characteristic and representative of similar low desert communities.

Concluding Remarks

The vegetative composition of the proposed and alternate solar-electric sites are characteristic of Creosote Bush Communities in southern Nevada. Vegetation similar in species composition and other vegetative features are continuous and widespread at elevations below 1220 m throughout the Mojave Desert. Similarly, vertebrate animals including reptiles, mammals, and resident birds are all characteristic inhabitants of these widespread communities. Due to their high mobility, large numbers of migratory birds characteristics of more mesic environments temporarily inhabit desert areas for varying periods of time.

No plants known from Harry Allen Station Study Area are considered to be rare or threatened. Two reptiles, the Desert Tortoise and Gila Monster are included on the state list of threatened species. The Desert Tortoise is relatively common to the Study Area as well as other low desert areas of southern Nevada. In our opinion, it is neither rare or endangered except possibly in the near vicinity of population centers or immediately adjacent to highways. The Gila Monster is listed as potentially occurring on the Study Area although none have been observed. The Gila Monster is usually associated with larger more mesic washes or river drainages but possibly could occur on or near the playa.

No birds found to date on the Study Area are classified as threatened or endangered. Nearly all species recorded, however, are protected by the federal Migratory Bird Treaty Act. Most others, hawk-like birds, Roadrunner and Owls are protected by state law. Two species, Gambel's Quail, and Mourning Dove are game birds in Nevada.

Two mammals, Spotted Bat and Kit Fox are on the state protected list and are considered rare. The Spotted Bat is listed as potentially occurring on the Study Area. The Spotted Bat prefers coniferous forests and usually is not encountered at the lower elevations in the desert except in riparian habitats. The few records for this highly habitat specific and highly secretive bat for the Las Vegas Valley are based upon sick or dead individuals. If present, utilization of the Study Area by this species is minimal.

The Kit Fox has been observed repeatedly on the Study Area. It is still common in many low desert areas of Nevada and is becoming rare only near population centers such as Las Vegas Valley where suitable habitat has been greatly altered.

In summary, of the four threatened or protected vertebrate species, only two, Desert Tortoise and Kit Fox, are found on the Study Area in appreciable numbers. Both are widespread and occur at comparable densities in suitable habitat which is widespread in other areas of low desert in southern Nevada.

2.10 ARCHAEOLOGICAL AND HISTORICAL SITES AND NATIONAL LANDMARKS

Archaeology

Consultants for Nevada Power (Ref. 2-1) established a study area including all of T.17S, R.63E and T.18S, R.63E, as well as those portions of T.17S, R.64E inside the Dry Lake depression. This study area therefore, comprises much more than Unit 1 of the proposed site, but only insignificant portions of Unit 2. The latter, for all practical purposes, remains to be studied.

The survey included a reexamination of four previously recorded archeological sites within, or adjacent to, the study area and a determination of whether additional archeological remains exist in the area.

The survey was conducted in accordance with Federal standards for mitigation of impact of construction activities on archeological resources on public lands. The survey was carried out under appropriate Federal and State of Nevada antiquities permits.

Literature and Record Search

A search was made of all published archeological literature, including the National Registry of Natural Landmarks for the study area. No references were found pertaining to archeological sites in either study area. The unpublished archeological site records of both the University of Nevada, Las Vegas Natural History Museum, and the Overton State Museum, Overton, Nevada, were searched. For Unit 1, the excavation notes for the Flaherty Site were found. As indicated below, the site is on the edge of Unit 1 in the NE1/4 of T.18S, R.63E. The site was previously excavated.

Field Surveys

For the areas, pedestrian surveys were conducted. For Unit 1, U.S. Highway 93 was used as a baseline. Transects spaced 100 m apart were laid out and walked from the highway to the western boundary of the area. Surveyors were spaced 15 to 20 m apart. Particular attention was given to cutbanks, drainage channels, and knoll tops. Low buttes with known small rockshelters were also checked. These are located at the south end of Area 1. One small, culture-bearing rockshelter was recorded and tested (see below). Others proved negative.

Testing Technique

In the two tested rockshelters, standard testing techniques were used. One meter square test pits were laid out, both inside and outside the shelter driplines. The test squares were excavated by trowels in 10-cm levels. All materials were passed through 1/4-in. (6.3 mm) wire mesh screens. Recovered artifacts were recorded by square and level.

Results

No surface sites or rockshelters were found within or near to Unit 1.

History

A survey of the National Register of Historic Places was conducted to determine the historical significance of the Dry Lake area approximately 40 km northeast of Las Vegas, Nevada. Literature on southern Nevada is scarce, especially for the period before 1905 when the San Pedro-Los Angeles-Salt Lake City Railroad (Union Pacific) was built.

The Old Spanish Trail and Mormon Wagon Road run parallel to old U.S. Highway 91 and are of historical significance, not only to southern Nevada, but to the west as a whole. There is a sign commemorating the trails at the junction of Interstate Highway 15 and U.S. Highway 93.

The San Pedro-Los Angeles-Salt Lake City Railroad was completed on January 30, 1905. Until the construction began, there was little, if anything, in the way of settlements between Las Vegas and Moapa. There is evidence of a railroad work camp that can be seen today in T.17S, R.64E, Section 8. Such communities as Dry Lake and Garnet are close to the station sites. Today, no one lives at Garnet, although the remnants of structures can be distinguished. Dry Lakes population usually consists of three families, although it appears there was a large community at one time. Dry Lake had a U.S. Post Office from December 3, 1925, until June 30, 1945, and again from January 31, 1950, until December 31, 1955. There is also some word-of-mouth information that a school was located in Dry Lake in the late 1930s. The community probably serviced not only the railroad but also the surrounding mines.

In reference to present-day mining activity in the area, there is a rather large operation at Apex. United States Lime Products Division of the Flintkote Company owns and operates a limestone quarry and a crushing and calcining plant that produces approximately 450,000 MT annually.

National Landmarks

No designated National Landmarks or National Monuments occur within or near either Units 1 or 2.

Conclusions

The area to be occupied by Unit 1 contains no archaeological sites. The Old Spanish Trail and Mormon Wagon Road run parallel to the old Highway 91 right of way. Such portions of these trails as still exist and seem to have historical value can be excluded from the plant area.

Unit 2 has not been investigated. A parallel study of that area would be required.

2.11 VISUAL VALUES

A scenic value and visual impact study of Units 1 and 2 and the entire surrounding region appears in Ref. 2-1. In summary the entire area envisioned for the plant is described as "below average" in scenic quality. Some nearby areas, particularly the Desert Canyon range, are described as "above average." Some of this range is visible from Interstate Highway 15 and U.S. Highway 93, in perspectives which would place the hypothetical proposed solar generating station in the foreground.

2.12 REFERENCES

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SECTION 3

RELATIONSHIP OF THE PROPOSED ACTION TO LAND USE PLANS, POLICIES, AND CONTROLS FOR THE AFFECTED AREA

3.1 CLARK COUNTY REGIONAL PLANNING COUNCIL

The Clark County Regional Planning Council has published no plans or controls for this land which would preclude the proposed action.

3.2 BUREAU OF LAND MANAGEMENT PLAN

The Bureau of Land Management (BLM) has developed a "Framework Plan," and documentation is available for inspection in the BLM Las Vegas office.

Among established land use plans, policies, and controls affecting this site, as collated and enunciated by the BLM, the following seem relevant.

Off-Road Competition

The BLM has designated this area as appropriate and authorized for off-road vehicle competitions. An off-road course has been laid out running from Crystal, on old U.S. Highway 91, under Interstate Highway 15, through Unit 2, west of the Dry Lake depression, and thence through Unit 1. An environmental assessment has been performed for this activity, and is available for inspection at the BLM Las Vegas office. In recent years, organized competitions have been staged which involved as many as 400 to 500 dune buggies and 200 to 300 motor bikes. This activity is destructive of vegetation, but certainly not to the extent that the proposed plant construction would be.

Continued off-road vehicle competitions in or near the solar generating station site, Units 1 and 2, would have to be prohibited, in order to avoid accelerated losses in generating capacity due to dust burdens on reflectors. Agreement to this effect would be required from BLM before a go-ahead decision could be made for this proposed action.

Sewage Effluent Lagoon

The city of Las Vegas has studied the possible use of the Dry Lake depression for a sewage plant lagoon. This use of the depression, while aesthetically offensive, would not necessarily affect solar station operation adversely.

Power Transmission Corridors

Powerline corridors exist in the area now, and additional ones are planned. Existing corridors are advantageous to plant design; additional corridors would have to be established in coordination with plant designers. If proper coordination occurs, there need be only minimal adverse effect on plant layout.

Power Plant Siting and Pipelines

Unit 1 has been determined to be an appropriate site for a 2000 MW coal fired power plant. There would be an associated buried coal slurry pipeline bringing 174×10^6 m^3 slurry water front Southwest Utah. The latter might run through Unit 2. A tertiary sewage effluent pipeline from N. Las Vegas would bring 1.18×10^9 m^3 of fluid to Unit 1.

It is possible that the proposed action could be located in the alternate site, perhaps largely in Unit 2, notwithstanding the presence of a coal fired plant in Unit 1. Very careful atmospheric dispersion estimations, and field opacity measurements, would have to precede a go-ahead decision.

Mining Claims

There is one mining claim in Unit 1: Old Witch Mining No. 1, owned by Hugh Issaacs, in T.18S, R. 63E, Section 11. This is about 1.6 km west of Interstate Highway 15, just northeast of U.S. Highway 93. Neither its value nor its validity have been investigated by BLM. The identity of the claimed mineral resource is not known to BLM. A shaft or drift mine at that location would not necessarily be inconsistent with the proposed solar generating station. A strip mine at that location would probably prevent utilization of a significant fraction of Unit 1 for the proposed power plant, but would not preclude plant construction further north.

Two mining claims exist adjacent to but not in, the alternate site outside of Unit 2. These are:

> Mamie Nos. 1 and 2 Placer, owned by Clarence Grant, and located in T.16S, R.64E, Section 7.
>
> Piute No. 9, owned by R. F. Barnal, and located in Section 6.

The nature of potential mining activities at those claims is not known. They both appear to be at high elevations in the Arrow Canyon Range. Any dust producing activity there could be avoided easily, since the alternate site is very much larger than our requirements.

SECTION 4

PROBABLE IMPACT OF THE PROPOSED ACTION ON THE ENVIRONMENT

4.1 ECOLOGICAL IMPACTS

by W. Glen Bradley

Ecological impacts resulting from construction and operation of the hypothetical solar-electric plant will be long termed and variable. These impacts will involve distinct changes in the physical environment, vegetation, and animal life now existing on the area. Each of these impacts will be discussed in appropriate sections.

Both the proposed and alternate solar-electric sites are areas with similar topographic and biotic features, although the alternate site does exhibit a more varied topographic diversity with a small northern portion of approximately 2 to 4 km^2 which would be unsuitable for plant construction. Also, the more northerm portions of the alternate site were not a part of the Harry Allen Station Study Area and were not studied. This northern area appears, however, to be quite comparable. It has been documented that biotic species diversity and abundance increase with elevation in the northern Mojave Desert of southern Nevada (Ref. 4-1). Therefore, it is expected that the alternate site will exhibit greater species diversity; hence the original site is more desirable for plant construction and operation. Either site, however, would have similar environmental impacts differing only slightly in degree of disruption of native biota. The following impacts will apply to either the proposed or alternate solar-electric sites.

Terrestrial Impacts of Construction

Construction will involve the movement and use of varying kinds of heavy equipment. Although this construction will occur in phases, it is reasonable to assume that most of the 52 km^2 square mile area will be significantly disturbed by equipment movement and/or construction. This disturbance will include assorted activities, such as drilling, digging, filling, leveling, and construction of roads, solar modules, and buildings. These construction activities, in conjunction with movement of heavy equipment, will cause drastic changes in soil surface and destroy much of the sparse desert vegetation now existing on the area.

Soils--

Desert soils are commonly protected from wind and water erosion by one of two surface layer features. In many areas, there is a layer of desert pavement composed of small rocks fitted together to form a mosaic on the soil surface. This layer has developed over long periods of time due to removal of soil particles from the surface by wind and the settling of rocks into position. Sometimes these rocks are cemented into place by chemical precipitates of soil leaching. This forms a relatively stable surface which may be largely devoid of any but perennial vegetation. This type of surface is relatively resistant to damage and can withstand such activities as movement of small vehicles and walking. This surface, however, would be greatly altered by movement of heavy equipment and/or construction activities.

A soil crust composed of desert lichens, mosses, and chemical sedimentation is a more common and widespread feature found throughout the Mojave Desert. This crust varies in thickness and stability dependent upon whether the basic chemical sedimentation is combined with soil lichens and mosses. This crust, however, is extremely vulnerable and easily broken, even by walking across the surface.

Areas not having these two surface features are overlain with soil particles which are unstable and easily eroded by wind and/or water. These two soil features are extremely important in preventing erosion. In areas where these soil surfaces have not been stabilized, erosion is a major ecological force due to the activities of strong winds and short, but intense rainfall which may result in both sheet and gully erosion. After stable soil surfaces are broken, they become unstable, and remain unstabilized and vulnerable to further erosion for decades. For example, army maneuvers performed by tanks during World War II in the Mojave Desert of southern California are still evident.

Vegetation--

Perennial vegetation in the low desert is very sparse with plant cover ranging from approximately 1 to 5%. Therefore, disruption of the sparse vegetative landscape does increase the intensity of erosion by wind and water.

Due to the fragile nature of the soil surface and sparse distribution of vegetation, the varied activities during construction would greatly alter the physical and vegetative landscape. This would result in severe erosion of the soil surface. Possible mechanisms to promote soil stabilization will be discussed under mitigative measures.

It is anticipated that much of the perennial vegetation present on the plant site will be destroyed during construction activities. It is highly desirable that extreme caution be used and construction practices be developed which will allow minimal damage to existing perennial vegetation. Regulatory attention may be required, together with management incentives at all levels of supervision.

To the extent consistent with brush fire prevention, small areas of existing vegetation should be maintained to promote revegetation following construction. It must be recognized that revegetation (plant succession) is very prolonged and highly variable in desert areas of low precipitation. When Mojave Desert vegetation is destroyed, several decades, and in some instances, more than a century, are required before natural or original plant cover is re-established (Refs. 4-2 and 4-3).

Desert environments present numerous difficulties for restoration once vegetation has been partially or totally destroyed. Even when sufficient vegetation is left which provide seed reservoirs for re-establishment, revegetation is greatly prolonged. This is due not only to erosion of the soil surface but establishment of invader species. Rainfall appears to be the dominant factor in revegetation success with above 25 cm of rainfall per year needed for successful revegetation under natural conditions (Refs. 4-4, 4-5 and 4-6). Rainfall on the construction sites is extremely variable from year to year, ranging from approximately 2.5 to 13 cm (Ref. 4-1). Therefore, it is expected that vegetative recovery will be extremely slow on the construction site unless mitigative measures are introduced.

Perennial vegetation over most of the construction site will be severely damaged or destroyed during construction. This will result initially in almost complete removal of perennial vegetation which provides almost all plant cover occurring on the area. Annual species (small herbs) germinate in winter and early spring and flower and develop fruit in spring and early summer. Species composition and density varies greatly from year to year dependent upon late winter and spring rainfall (Refs. 4-7 and 4-8). Plant cover for annuals in the low Majave Desert and of southern Nevada usually ranges from 0.3 to 3.0% (Bradley, unpublished data). After initial removal of much of the perennial vegetation, desert annuals should increase greatly in density. This is due not only to decreased competition with perennials for available water but also to disturbance of the soil surface which provides a more ideal environment for germination of annual seeds. This increased density of annuals, however, will provide only minimal stabilization of the soil surface due to only seasonal occurrence on the area.

Along with the increased density of annuals, there will be appreciable development of non-native invader species, comprised mostly of annuals. Important non-native species which may achieve high densities and biomass on the area will include Russian Thistle (Salsola spp), grasses (Bromus rubens and B. tectorum), and Storkbill (Erodium cicutarium). Within a few years after initial disturbance, these invaders will provide more plant cover than native, annual vegetation. The extent to which this growth would cause an intolerable fire hazard has not been investigated. Indeed, it is not clear that grass fires would damage modules, PCM's or battery houses if clear zones about these are maintained.

Vegetative succession after the initial invasion of annuals is varied especially in terms of time, but usually relatively simple in terms of species composition. At some undetermined time, perennials such as Desert Marigold (Baileya spp.) Cheese-weed (Hymenoclea salsola), Matchweed (Gutierrezia spp.) and Desert Mallow (Sphaeraclea ambigua) will become established. These species, while present in Creosote Bush Communities, more commonly occur along desert washes or other disturbed areas. Further seral stages leading to the climax Cresote Bush Community have not been adequately described, and both their species composition and temporal duration are unknown. Plant succession leading to the climax community, although inadequately described, may exceed 100 years in duration. Because the solar array will cause shading about each module (cf. Section 4.2), revegetation will never be re-established with identical geographic distribution of species.

Vertebrates--

Disruption of the soil and native vegetation by construction activities will result in highly varied but significant changes to the vertebrate fauna presently occupying the solar-electric sites. During phases of construction much of the habitat requirements of individual species, such as food, shelter, and resting sites, will be removed. This will result in drastic reduction in individual populations due to increased mortality and dispersal from the construction area. Modification in population levels will vary greatly between species largely dependent upon home range size, range of normal movement, shelter and food requirements, and habitat specificity. It must be realized that vertebrate populations may be largely interrelated through food webs and other biotic relationships and decrease in population of an individual species may affect population levels of other species.

As far as an individual species is concerned, several possibilities exist after drastic alterations of habitat by construction activities. If the species is not habitat — specific or utilizes the area only for a portion of its life requirements, population levels may remain similar to those before construction. An example would be the various species of bats which utilize lower desert Creosote Bush Communities primarily for foraging activities.

Their food supply, largely made up of volant insets, would still remain on the site, although perhaps in reduced densities, and occupy areas of similar habitat. Bats have high mobility and forage over large areas; hence, population number and species composition of the lower desert bat fauna would not be significantly altered by alteration of the landscape in the plant.

Larger carnivores such as the Coyote (Canis latrans), Gray Fox (Urocyon cinereoargenteus), Kit Fox (Vulpes macrotis), and Bobcat (Lynx rufus) range widely, are not habitat specific, and would primarily move into adjacent areas of Creosote Bush Community in response to diminished food supply (rodents and rabbits) and disturbance due to construction activity. Current plans call for the plant to be surrounded by a perimeter fence to exclude large animals and trespassers This fence would make it difficult for the larger carnivores to disperse back onto the sites if and when population levels of prey species became adequate to sustain predator populations. It is possible that some may burrow under the fence. It is also possible that some deliberate effort may be required in order to re-establish these predator species, especially if rodent and rabbit populations become a problem. Such efforts might include construction of small gaps in the perimeter fence. Another possibility is live trapping and relocation with the cooperation of appropriate Federal and Nevada wildlife managers. As compared to the previously mentioned carnivores, Badgers (Taxidea taxus) have reduced mobility and are directly dependent upon burrowing rodents as a food source. Hence, their presence, absence, or depleted population levels within the plant would be directly related to burrow rodent populations, as well as the extent to which the fence prevented their re-establishment. The Skunk (Spilogale putorius) is a small carnivore not commonly found in Creosote Bush Community except along major desert riparian environments and mesic habitats.

The only large ungulate reported for the general area of the construction sites is the Desert Bighorm Sheep (Ovis canadensis nelsoni). This species is present throughout much of the higher elevations of the Arrow Canyon Range which is adjacent to the plant sites. Some movement does occur across low elevation desert to the Sheep Range situated across the valley to the west of Arrow Canyon Range. Sheep, however, do not normally move into low desert east of Arrow Canyon Range where construction sites are located. Hence, they would have occurred on the construction site only rarely. Therefore, normal movements would not be impaired by construction activities or perimeter fencing.

A majority of the 70 species of birds found in the vicinity of the construction site are transients (migratory), visitants, or seasonal residents. Bird distribution, especially in relation to species diversity, is closely related to the heterogeneity present in the vegetative landscape which provides shelter and resting sites (Ref. 4-9). Due to their wide ranging foraging activity, local food supply is of secondary importance for both density and species diversity. Therefore, after initial removal of much of the vegetative landscape, which provides habitat, both population levels and species diversity would be greatly curtailed on the solar-electric site. Birds normally utilizing the area would then occupy adjacent areas of similar habitat which are widespread and continuous. Birds would begin to use the construction site to varying degrees as vegetation became re-established.

Small mammals, such as rabbits and rodents, have reduced home ranges and their long-termed presence on the construction sites would largely be dependent upon the extent of vegetative recovery. During construction, not only would their food supply be drastically reduced by removal of browse, but much of the seed reserves located at or near the soil surface would be covered over. Also a majority of the rodent burrows would be destroyed as well as vegetative shelter for rabbits. These losses in food supply and shelter would greatly disrupt normal activity patterns resulting in high mortality and dispersal from the construction areas. Only a sparse population of rodents and rabbits would be expected to survive on the solar-electric sites upon termination of construction. Initial establishment of invader plant species and eventual native annual plant production would provide an abundant food source for both rodents and rabbits. Rabbits especially would be expected to develop high densities adjacent to construction sites and utilize heavily the abundant green, succulent forage found on the edge of solar-electric sites. Reestablishment of residency on the plant site, however, would depend upon sufficient recovery of perennial vegetation to provide an adequate distribution of shelter and shade sites throughout the area. In contrast, however, the disturbed soil surface following construction would provide an ideal environment for the establishment of new burrows by rodents. Species composition and densities of the rodent fauna returning to the solar-electric sites would be different from those previously found under undisturbed conditions. Species believed to reestablish themselves at high densities on areas of the low desert are Merriam's Kangaroo Rat (Dipodomys merriami) and Antelope Ground Squirrel (Ammospermophilus leucurus), which are both characteristic of the Creosote Bush Community (Refs. 4-10 and 4-11). Continued changes in rodent densities and species composition would be expected during the various phases of vegetative recovery.

Reptiles are another major group of vertebrates of limited mobility with many species having reduced home ranges. Snakes have relatively large home ranges for reptiles, as they forage widely for prey species primarily composed of rodents of rodents and lizards (Refs. 4-12 and 4-13). Species composition and densities are largely related to food supply, and dispersal should occur from the construction sites due both to depletion of food resources and destruction of shelter and hibernals. Reestablishment on the areas of a characteristic snake fauna would coincide with vegetative recovery and population densities of prey species.

The Desert Tortoise (Gopherus agassizi) is herbivorous and forages widely on a variety of desert plants. Each individual uses a large number of burrows both for daily shelter and for hibernation. Construction activities would not only remove most of the forage, but also destroy the majority of burrows, sometimes during occupancy. Unless mitigative measures are introduced, construction would result in high mortality, especially if construction occurs during periods of hibernation. Surviving Desert Tortoises would disperse into adjacent areas surrounding the solar-electric sites where hopefully they could find abandoned burrows or construct new ones. Reestablishment of viable Desert Tortoise populations on the solar-electric sites would occur only if vegetative recovery approaches natural conditions.

Lizards have the most restricted movements and smallest home ranges of any reptiles found in the area and are largely dependent upon perennial vegetation and abandoned rodent burrows for shelter and hibernal sites (Refs. 4-14 and 4-15). Heavy mortality involving destruction of shelter is to be expected during construction, particularly during winter months when practically all species are hibernating. Reestablishment of the characteristic lizard fauna on the solar-electric sites would occur only after establishment of rodent burrows and perennial vegetation for shelter.

Aquatic Impacts of Construction

The proposed solar-electric sites lie immediately adjacent to the drainage into Dry Lake playa. The central portion of the playa becomes a temporary lake for varying periods of time only after high intensity rainfall occurs in the surrounding area. An appreciable body of water (lasting over an extended period of months) is present in years of high rainfall, occurring at irregular intervals. The playa may remain essentially dry for periods of several years. Construction activities, especially leveling, road building, and placement of solar modules may disrupt patterns of existing drainage on to the playa. If heavy rainfall occurs during construction or before some soil settling and stabilization have occurred, erosion may be a major factor on the area. Also the sediment load from drainage onto the playa would be increased due to the erosion of loose soil. Disruptions of natural drainage by construction would have little permanent effect since new drainage channels would become established over a period of years resulting in normal drainage to the playa.

The ephemeral, aquatic fauna found on the playa is restricted largely to crustaceans which form resistant eggs that can withstand desiccation for several years. Adult forms are only found during periods of temporary water. The total amount of water discharge on to the playa would be little affected by plant construction, and the initial increase in sediments would have little effect on the aquatic fauna since it is adapted to highly turbid levels.

Terrestrial Impacts of Operation

The ecological consequences of continued plant operations are minimal when compared to the drastic alteration of soil surface, vegetation, and animal life resulting from construction activities.

The period of plant operation will involve only minimal disruption of the area due to use of roads for inspection and maintenance. Any major repair of existing modules or other installations involving the use of heavy equipment would further alter the soil surface, vegetation and habitat of animals. Major repairs, however, are expected to be minimal, and routine inspection should result in little further or continued damage to the environment.

Both wind and water erosion will be greatly accelerated during early phases of plant operation due to the removal of perennial vegetation, soil crust, and desert pavement. Before soil stabilization the effects of water erosion upon the plant site are highly unpredictable due to highly variable yearly precipitation patterns. If high intensity rains occur, they may well produce gullying to the extent of undermining solar modules and/or causing road damage. The effects of water erosion will diminish with time with the reestablishment of perennial vegetation and soil stabilization. Wind erosional effects will also be pronounced during the early phases of plant operation before stabilization of soil and vegetation. To some extent, the placement of modules may disrupt wind patterns, modifying their intensity. It is expected, however, that wind blown soil will accumulate around the leeward base of modules, and if sufficient accumulation occurs, this soil may interfere with their movement. Wind erosion will diminish as soil surface and vegetation become reestablished. Deliberate introduction of selected plant species to reduce soil movement is a possibility which we have not investigated.

Placement of solar modules would result in greatly increased shading over an appreciable amount of the solar-electric site. Shading patterns would be highly variable, dependent upon time of day and season, with areas directly under modules in permanent shade. The major effect of this greatly increased shading would be decreased evaporation of water from the soil surface and reduced transpiration from existing vegetation. Additionally, rainfall spashed from modules would fall in the area outside of the foundation ring,[*] thereby providing a mesic boundary around the rotating portion of each module. This area would be ideally suited for revegetation of both annual and perennial plant species due to increased water availability. Initial vegetative establishment would be of typical invader or weed species, such as brome grasses and Russian Thistle. The sequence of seral stages in these shaded areas is unknown and to what extent they might involve species not characteristic of Creosote Bush Communities is probably dependent on seed dispersal. The most probable successional sequence is an accelerated reestablishment of characteristic vegetation which would grow more rapidly and achieve larger individual plant size than on the non-shaded portions of the plant site.

The placement of modules over a large area will provide little interference with development of vegetation and reestablishment of characteristic small vertebrate populations in the area between and adjacent to solar modules. The mesic boundary immediately adjacent to the module should provide ideal habitat for arthropod populations and abundant seed and browse for forage by rodents and rabbits. Crevices at the base of each module will provide additional habitat for arthropods, lizards, snakes, and perhaps small mammals. The shaded portions of the modular support structure may provide nesting sites for breeding birds as well as roosting sites for some species of bats. If sufficient recovery of vegetation is achieved, the placement of modules can be considered as a means of increasing the environmental heterogeneity of the Creosote Bush Community, possibly resulting in a more varied biota than under natural conditions.

However, the reestablishment of small vertebrates will have to be monitored in the module groups which are installed first. Possibly burrowing animals and nesting birds could interfere with module performance.

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[*] Most rain striking the modules will drain into gutters and be directed onto crushed rock pads within the foundation ring.

The probable reestablishment of vegetative and animal life for non-shaded areas has been described in the section, Terrestrial Impacts of Construction. It is emphasized that routine inspection and maintenance would not appreciably alter these natural processes.

Offsite Aquatic Impacts of Operation

Ecological impact due to drainage from the construction sites into Dry Lake playa, the only aquatic environment present adjacent to the study area, has been discussed under the section, Aquatic Impacts of Construction. Following construction, any obstructions to previous drainage patterns onto the playa from the solar-electric sites will be overcome by the development of new and adequate drainage. No long lasting, detrimental effects are expected on the ephemeral fauna of Dry Lake playa due to plant operation.

Absence of Thermal Pollution Effects

Ecological impact due to thermal discharge will be essentially nonexistent. Total heat rejection (from discharging and charging) is relatively low and will be spread over the entire site. In comparison to the heat dissipated by an equivalent coal-fired plant, solar-electric modules release approximately 90% less heat to the surrounding environment. It is highly unlikely that the vegetation, soil, or animal life will be adversely affected by the relatively low thermal discharge of the solar-electric plant.

Conclusions

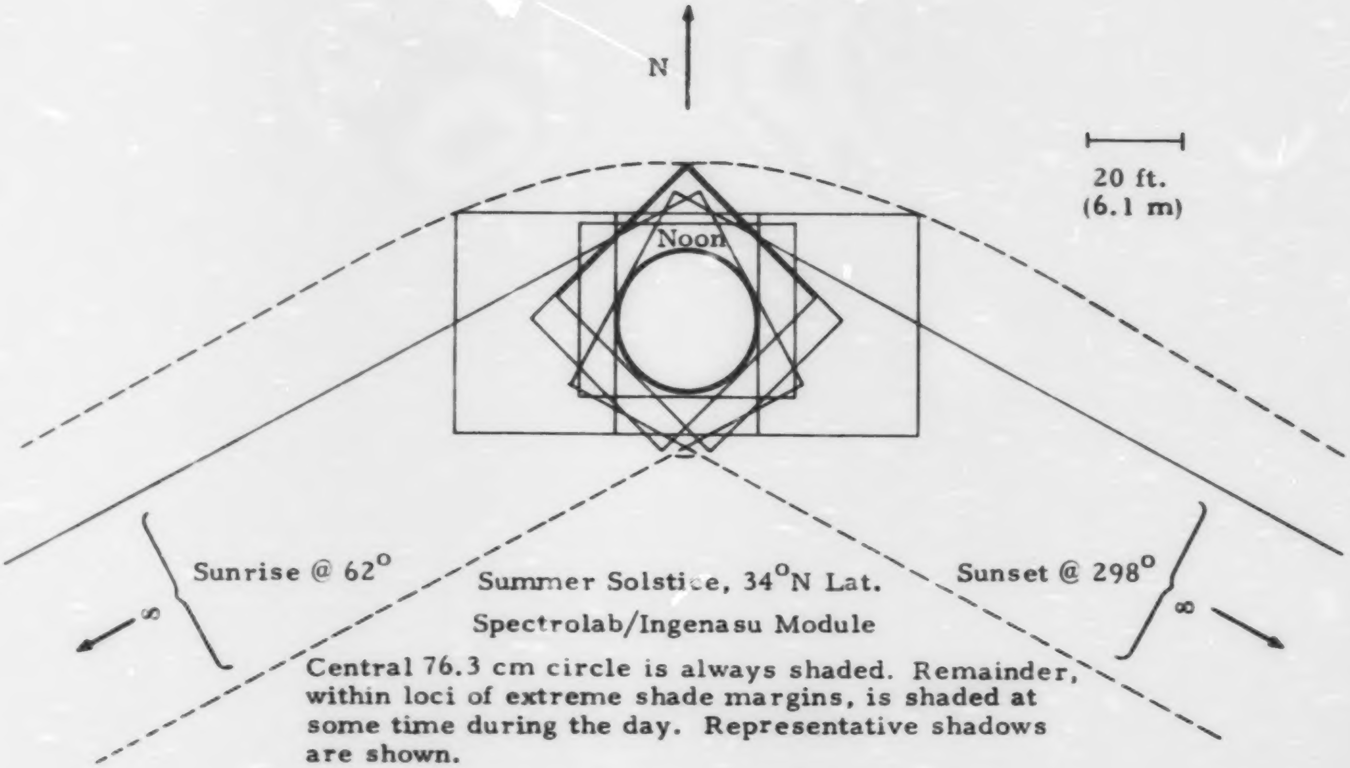
The major ecological impact will be terrestrial on the solar-electric sites, whereas aquatic impacts will be minimal. Additionally, the most pronounced alteration of environment will occur during construction phases when much of the protective soil layer will be destroyed and much of the perennial vegetation removed. Although construction methods should be used that provide minimal destruction, it is recognized that soil surface and vegetation changes will be a major impact upon the area and will be of extremely long-term duration. The removal of surface crust and vegetation during construction will be accompanied by destruction of shelter and reduction of food resources for much of the animal life on the area. High mortality and dispersal from the area by wildlife is to be expected.

Following the massive alteration of habitat on the solar-electric sites during construction, the effect of plant operation will be minimal or virtually nonexistent and will allow for extremely slow recovery of the environment through revegetation and soil stabilization, accompanied by the reestablishment of a characteristic desert fauna. Recovery of the environment to a near natural condition, however, is expected to take an extremely long period (approximately 100 years). The successional stages of vegetative recovery may be greatly enhanced by mitigative measures.

No plant species on the proposed or alternative solar-electric sites may be considered rare or endangered. Two animal species, Desert Tortoise and Kit Fox, are either on the threatened or protected state list of Nevada. Desert Tortoises (on the threatened list) are common on the solar-electric sites and heavy mortality is expected during construction, especially during fall, winter, and early spring months when hibernation occurs. The Kit Fox (on the protected list) is becoming uncommon to rare near cities or other developed areas in the Mojave Desert. It is, however, still a common carnivore over much of the low desert where its habitat has not been altered. It is common on both the proposed and alternate plant sites and would be expected to disperse from the site during and following construction as its food supply (rabbits and rodents) decrease. A wide expanse of suitable habitat is found adjacent to the solar-electric sites.

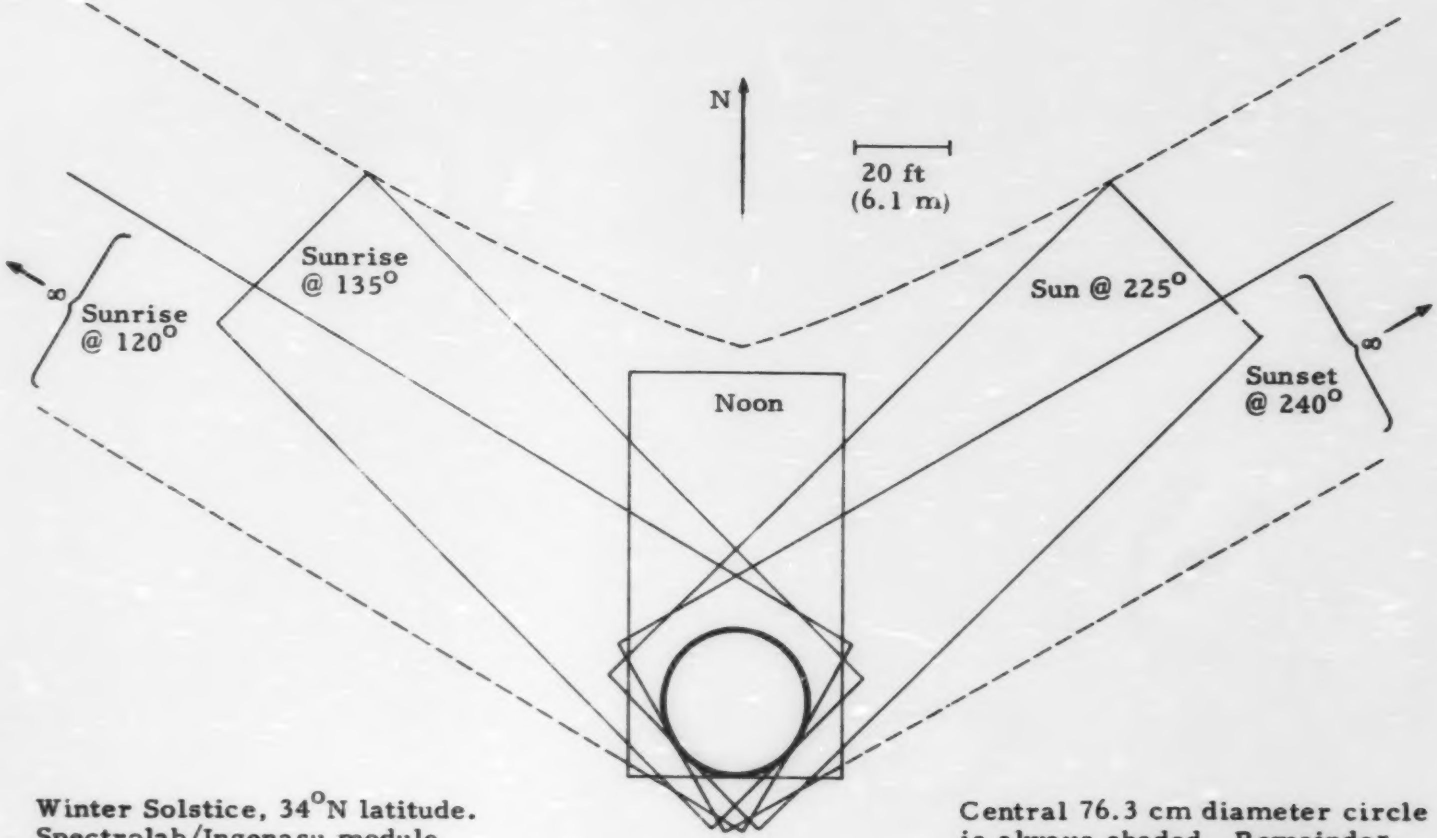
4.2 SHADING BY SOLAR MODULES

Depending on the time of year, each of the 50,000 identical modules' shadows will sweep out identical paths across the adjacent ground determined by the modules' dimensions and the sun's apparent trajectory. Some representative shadows and the loci of shadow extrema are depicted schematically in Figures 4-1, 4-2 and 4-3 for the summer and winter solstices and spring


N
20 ft.
(6.1 m)
Noon
Sunrise @ 62°
∞
Summer Solstice, 34°N Lat.
Spectrolab/Ingenasu Module
Sunset @ 298°
∞

Central 76.3 cm circle is always shaded. Remainder, within loci of extreme shade margins, is shaded at some time during the day. Representative shadows are shown.

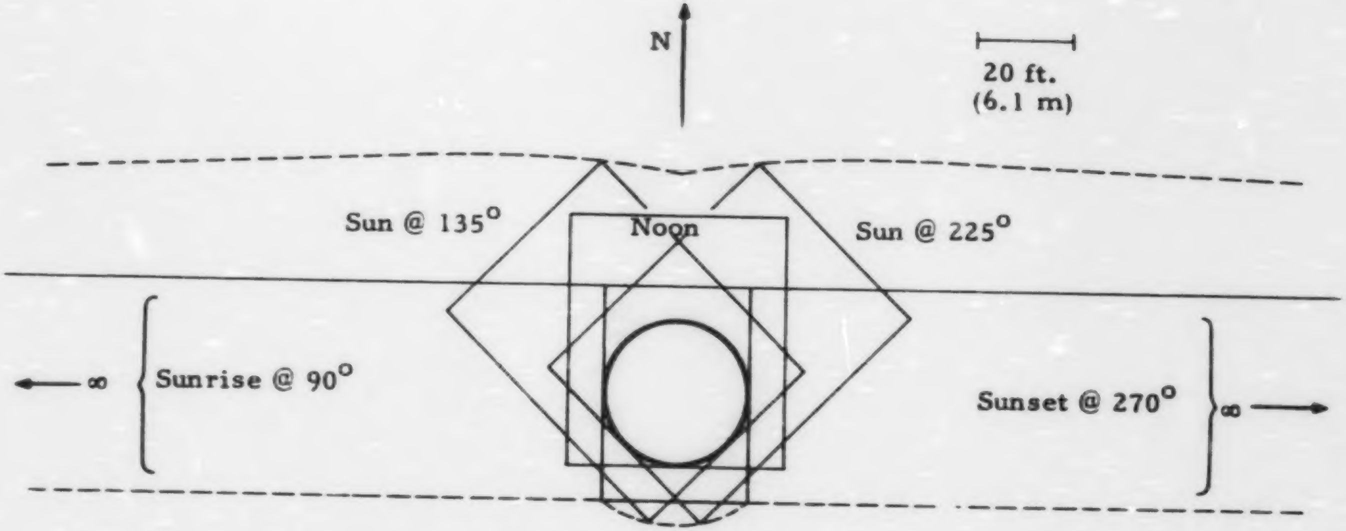
Figure 4-1. Module shadows and loci of shadow extrema for summer solstice.


N
20 ft
(6.1 m)
Sunrise
@ 135°
Sunrise
@ 120°
∞
Noon
Sun @ 225°
Sunset
@ 240°
∞

Winter Solstice, 34°N latitude.
Spectrolab/Ingenasu module.

Central 76.3 cm diameter circle is always shaded. Remainder is shaded at some time during day; boundaries are loci of extreme shade margins. Representative shadows shown.

Figure 4-2. Module shadows and loci of shadow extrema for winter solstice.


N
20 ft.
(6.1 m)
Sun @ 135°
Noon
Sun @ 225°
∞
Sunrise @ 90°
Sunset @ 270°
∞

Spring and fall equinoxes (~3/21 and 9/21), 34°N latitude. Spectrolab/Ingenasu module. Central 76.3 cm circle is always shaded. Remainder, within indicated loci of extreme shade boundaries, is shaded during some portion of day. Representative shadows are shown.

Figure 4-3. Module shadows and loci of shadow extrema for spring and fall equinoxes.

and fall equinoxes.[*] Because the modules rotate about only a vertical axis so as to track the sun, but do not alter their inclination, the shadow loci are not determined simply. In Table 4-1 we present the numerical data from which Figures 4-1, 4-2 and 4-3 were constructed, in part. The effects of this shadowing include:

a. Primary ecological effects related to species' preference for shadow or sunlight
b. Effective "mulching" by the solar array which, in effect plays the role of a synthetic boulder field
c. Increased moisture retention (reduced evaporation) and reduction in soil heat due to (b)
d. Secondary ecological effects arising from (c) above
e. Secondary ecological effects related to defensive cover (concealment) afforded by module shadows.

None of these effects is presently quantifiable. The "mulching" and consequent increased moisture retention and reduced soil heat are capable of modeling or experimental determination, but this has not been done. The land surface will be altered by construction. The altered surface must be used in any modeling or experimental program; because of erosion and vegetation changes, this surface will itself be changing. Further aspects of shadowing are discussed in Sections 4.1 and 5.7.

As reported in Section 2.5, the 2 to 3 in. deep vesicular layer on the soil surface greatly reduces downward heat transport and dissipation; this creates a major obstacle to establishment of any but the most heat resistant seedlings. Shadowing will reduce soil heat. This, coupled with some slight increase in moisture due to rainfall splash from modules will encourage revegetation. This is discussed in Section 4.1. At present 80% of the species occurring naturally are found only on stony situations (Ref. 4-16) which this array may approximate.

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[*] These figures were developed for 34°N latitude (the actual plant site runs from 36°23' to 36°35' N latitude, approximately) for which astronomical data were in most convenient form. For small latitude changes, small changes occur in the shadow loci. The north-south components of cell shadows is longer at higher latitude, for example.

TABLE 4-1. SHADOW LENGTHS FOR 10.4 HIGH STRUCTURE AT 34°N LATITUDE

Sun Azimuth, deg	Sun Altitude, deg	Shadow, ℓ, m	Time of Day
Summer Solstice			
62	0	∞	Sunrise
90	45	10.4	
135	76	2.6	
180	80	1.8	Noon
225	76	2.6	
270	45	10.4	
298	0	∞	Sunset
Spring and Fall Equinoxes			
90	0	∞	Sunrise
135	47	9.7	
180	56	7.0	Noon
225	47	9.7	
270	0	∞	Sunset
Winter Solstice			
120	0	∞	Sunrise
135	16	36.2	
180	32	16.6	Noon
225	16	36.2	
240	0	∞	Sunset

4.3 THERMAL POLLUTION

As described in Section 1.2, a charge-discharge cycle for the batteries involves a 20% loss. With three hours storage capacity, this is 240 MWhr (8%) waste heat released to the environment during charging, and 360 MWhr (12%) during discharge. Discharge is likely to occur more frequently at its maximum rate, 120 MW, than is charging. Charging may be done in increments during late p.m. and early a.m.

By comparison, a moderately inefficient 1000 MW coal-fired plant would reject waste heat at the rate of almost 2000 MW. Normalizing both plants to eight hours generation, a fossil fuel plant rejects nearly 27 times more heat than does a photovoltaic solar plant. Additionally, the heat rejection by conventional power plants is concentrated at cooling towers and/or in thermal plumes in natural surface waters. This solar plant's waste heat release is spread over 52 km^2. This corresponds to perhaps a hundredfold reduction in the areal intensity of the effect.

Further small quantities of waste heat are rejected by the silicon absorbers, which run at a steady state temperature of ~100 C. This, however, is energy which would have been reradiated in part by soil were there no solar plant. The overall efficiency of this solar plant corresponds to an albedo within the normal range of soil types: 15% loss as visible radiation at the primary and secondary reflectors, and another 68% partly (perhaps mostly) as heat at the absorber. The total, 83%, is spread over an areal receiver density of about 16%, and is in addition to the heat radiated by the uncovered 84% of the land area. Assuming all unutilized light is emitted as infrared radiation or lost convectively the heat budget is therefore ~83% rejection over 16% of land area plus bare earth albedo loss over 84% of the land area. Averaged over the entire array field (modules plus soil), the net effective albedo loss, α, would be

$$\alpha = 0.84 \times \text{bare earth albedo loss} + 0.16 \times 0.83$$

Bare earth albedo losses range from 0.70 to 0.97. Taking ~0.85, we have $\alpha \sim 0.84$, well within that range.

4.4 VISUAL EFFECTS

This installation extends from U.S. Interstate 15 almost to the Arrow Canyon Range to the west. Each module is about the size of a small house. Center-to-center spacing on the square grid is 33 m. In every 10 x 10 group of modules, there are two low block buildings containing batteries and power conditioning equipment.

We can envision the visual effect as that of a city of 50,000 small homes arrayed over a perfectly uniform square block pattern on flat terrain. There is no way to hide such a scene, at its proposed hypothetical location.

Lovers of the openness and wildness of the undisturbed desert may be displeased. Nevertheless, we expect this installation to be, for a time, a tourist attraction for those people who visit works of man such as Hoover Dam. Moreover, there do not appear to be any productive alternative uses for this land which would not cause greater potential scenic deterioration. Nevertheless, aesthetic acceptance of this plant is subjective and therefore subject to great variations in individual acceptance.

4.5 ATMOSPHERIC EMISSIONS

Other than thermal emissions, discussed in Section 4.3, the following potential sources are identified:

- Battery houses, in the event of fire. Emissions could include Li_2O or LiOH, Al_2O_3, SO_x, and other combustion products. Cell constructions seems to make fire a very improbable event. Modular construction limits a fire to a small unit.
- Degraded plastic and adhesive in primary collectors. Both photolytic and thermal decomposition are possibilities which must be considered (cf. Section 1.2). Without additional information on plastics and adhesive composition, we can only suggest that emissions may include unsaturated hydrocarbons, halogenated organics, organic acids, alcohols, and other oxidized species. Identification of emissions and transport modeling for this distributed source would have to precede an evaluation of occupational hygiene effects, public health effects, and ecological effects. It seems very unlikely that any reflector material whose use is economically justifiable would suffer rapid enough degradation to create an air pollution problem (cf. Section 1.2).
- Diesel generators. These would be used during construction, particularly for welding, and for emergency plant power. Exhaust emissions can include CO, NO_x, hydrocarbons, particulates, aldehydes, organic acids, and SO_x. These can be quantified if the number and size and characteristics of such generators is defined. These are expected to be a minimal, indeed negligible air pollutant source, even during construction.

- Fugitive dust during land preparation and construction. We identify this as the only signficant air pollution problem associated with the project. It does not differ in kind, or extent from that observed in large highway construction projects, for example. Although economically unattractive, there exist hygroscopic dust suppressants and chemical binding agents. We do not believe their use is either necessary or justifiable during construction. Further, they introduce a foreign substance capable of being transported by run-off waters.
- Vehicular emissions during construction.
- Fugitive emissions from quarrying, cement manufacture, and concrete batching. About 10^6 m^3 of concrete, on an average of 10^5 m^3/yr must be batched and transported to construction sites. Nearly 10^6 MT of steel must also be transported. We anticipate that much of the steel will be delivered by rail. Concrete may be batched on-site. Analysis of these pollutant sources more properly awaits resolution of the vast logistical problems arising from this project.

  In addition, about 1000 workers will be commuting from the Las Vegas vicinity daily, adding to the vehicular burden.

As compared with conventional generating stations, the following air pollution effects will be absent:

- Combustion products
- Drift and fog from cooling towers
- Breeze (airborne dust) from coal piles and radiochemical discharges from nuclear reactors.

Absence of appreciable air pollution, together with complete freedom from process water requirements, constitute the two most important direct environmental advantages of solar-photovoltaic power generation.

4.6 EROSION

Both wind and water erosion will be affected. Surface wind velocities will be reduced substantially (Ref. 4-17) because of increased "roughness." Therefore, this project would seem to have a beneficial effect on wind erosion after vegetation is reestablished and surface soil consolidation has occurred. Both processes, however, are very slow in the desert environment. We have no estimate at hand on the severity of the wind erosion problem. A substantial body of experience surely exists among major Southwestern engineering construction and agricultural engineering firms. This experience seems likely to be more useful than experiments or simulation, and should be drawn upon.

Water erosion is unlikely to be severe. The terrain is level and the soil permeable. Natural drainages will be maintained undisturbed to the maximum extent possible. Hard rains seldom occur (cf. Section 2.6, Figure 2-3).

4.7 WATER QUALITY AND SUPPLY

No appreciable effect upon groundwaters has been identified which fails to meet public health standards. In practical terms, there is no surface water at, or near, the site.

A source of construction water has not been identified. Such water will have to trucked to the site after purchase by the concrete batch plant subcontractors and is subject to permits, appropriations, etc.

4.8 LAND USE

This matter is discussed in Sections 2, 3, 6 and 8. The land has no present or forseeable productive use in the absence of the project. Therefore, the proposed action constitutes a beneficial conversion of wasteland to productivity.

4.9 NOISE

As distinct from turbogenerator installations, there is no large high speed rotating equipment.

Module drive motors will be small low horsepower ac motors (probably about 1 hp) driving high reduction ratio gear boxes. No noticeable motor noise is anticipated at the perimeter fence. Other noises (60 cycle hum, maintenance vehicles) are considered minor and completely overwhelmed by highway traffic and military jet noises.

4.10 WASTE DISPOSAL

This installation generates no process waste streams. Sanitation wastes during construction are hauled away and during operation are given secondary treatment by small package plants.

4.11 TRANSMISSION LINES

No new transmission lines are planned. Existing lines in the existing corridor adjacent to the plant will be used.

4.12 EFFECTS ON LOCAL HISTORIC OR CULTURAL AMENITIES

None. (cf. Section 2.10).

4.13 EFFECTS ON LOCAL AND REGIONAL DEMOGRAPHIC, SOCIO-ECONOMIC, AND COMMUNITY CHARACTERISTICS

Population Effects

A maximum construction work force of approximately 1000 craftsmen and supervisors is anticipated. This level would be maintained for about 7 to 8 years of the projected 10-year project.

Clark County Regional Planning Council Projections for population growth envision a flat rate growth of $16{,}200\ ^{+3{,}300}_{-2{,}600}$ per year in the period 1977-2000. Even including dependents, the population effect of this project will be trivial. In as much as "alternative" power plants would be required were this hypothetical plant not "built," it seems that the population effects do not merit attention.

Municipal Services

The environment surrounding the proposed plant is both fragile and inhospitable. There are now in existence no communities near the site. We propose to actively discourage any development of construction villages. By providing bus service from Las Vegas, by firm persuasive efforts with contractors and subcontractors, and by any other exhortations at our disposal, we will attempt to dispose the entire work force to settle in the Las Vegas urban area primarily, and Henderson and Moapa Valley communities secondarily. The latter have suffered declining populations recently, and only Overton (pop. ~1300) can absorb an appreciable influx.

Because the projected Clark County population increase is expected to overwhelm the plant construction crew contribution, we anticipate no area-wide problems with municipal services. This would include water, sewerage, hospitals, schools, etc. Consult Section 2.2 for tabulations of presently available and projected facilities.

Although area-wide problems are not expected, it is probable that local shortfalls will occur. This is particularly true in Moapa Valley towns and school districts and small communities in the Las Vegas urban area.

Manpower

Table 2.2 and 2.3, Section 2.2, present data relative to the size and characteristics of the locally available labor force. The atypically small percentage of craftsmen, especially cement masons, electricians, linemen, ironworkers, and operating engineers, suggests that an infusion of craftsmen into the economy is an almost certain consequence of this hypothetical project. Typically these craftsmen will have higher wages than service industry personnel. Consult Section 2.2 and Ref. 4-18.

Infusion of Capital

Much of the $\$1.67 \times 10^9$ capital investment for this plant will be spent at distant locations where collectors, absorbers, and superstructures and power conditioning equipment are fabricated. We estimate that less than \$300 M (including \$220 M contingency) could be spent locally in a normal community. The absence of a substantial local manufacturing industry suggests that the project will have smaller financial impact. Detailed analysis is possible, but outside the scope of this task.

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SECTION 5

ALTERNATIVES TO THE PROPOSED ACTION

5.1 GENERAL

The proposed facility is a hypothetical utility-size solar electric plant utilized solely to assess its potential environmental impact. The primary criteria used in selecting the plant site were that it be typical of a site likely to be used for the first large (utility size) solar electric plant and a baseline environmental study be in existence for the site. A site northeast of Las Vegas, Nevada, was chosen because it satisfied these criteria.

We reemphasize here, as elsewhere, that this environmental impact statement (EIS) is for a hypothetical plant. The specific area was selected because Nevada Power Company has an active proposal and plans to construct a 2000 MW_e coal fired steam electric plant at this site. In preparation for the project, Nevada Power and its contractors and consultants prepared an extensive environmental assessment (Ref. 5-1) that contains nearly all the baseline data needed for this EIS. We make extensive use of Nevada Power's baseline studies by their permission and by permission of the Bureau of Land Management.

The status of construction plans for the coal fired plant (the "Harry Allen Station") is not affected by this report.

The design concept, described previously in Section 1, represents a conceptual blend considered typical of a future large photovoltaic power plant. The design features and characteristics are largely based on presently available design studies conducted by and for Spectrolab, Inc.

5.2 NO ACTION

This alternative is not consistent with established U.S. national goals of achieving energy independence. These goals require development of new sources of energy to augment present sources. Projected growth patterns in the U.S. Southwest support the need for additional generating capacity.

5.3 FEASIBILITY OF LARGE POWER IMPORT

Treatment of this alternative is not within the scope of the present effort.

5.4 REACTIVATION OR UPGRADING OLDER PLANTS

Treatment of this alternative is not within the scope of the present effort.

5.5 ALTERNATIVE SITES

The characteristics of a solar-electric plant are sufficiently different from the conventional coal fired steam electric and nuclear power plant to bias strongly the choice of sites for the plant. Land use and amount of insolation are prime factors to be considered. Collector area required for a utility size plant is measured in thousands of hectares. The terrain should be such that the slope maximizes the insolation and minimizes shading of the collectors to maximize daily operation. A gentle uniform slope to the south would be ideal. Plant sites located in hilly or mountainous terrain can shorten the daily exposure of the collectors. Because of the large land area required, the increased land preparation costs in hilly terrain prohibits its consideration in the foreseeable future.

The large land area required for the solar-electric plant will necessitate some type of access system to each solar module for routine maintenance and servicing. Access can be either by road or some type of rail system. In either event the road bed will have to support heavy equipment for servicing the large solar modules which will weigh about 12.7 MT. The road access system is greatly simplified if the planform is rectangular and compactness is maintained. If the terrain necessitates irregular planforms or separates various modules by hills, the access system and transmission lines to the main switchyard will be more complicated.

A solar electric facility which provides power for a network should be considered relative to the main transmission lines within the network. Transmission losses are minimized if the facility is located as near as possible to the main lines. The same holds for a facility which services a particular load center.

An obvious environmental consequence will be land use and modification to the local ecosystems. The first solar-electric plants will probably be located in the Southwestern United States. Much of this region is arid desert where land use relative to population density is not the problem it could be along the eastern seaboard, for instance. Considerable shading of the terrain surface by the collectors can be expected. This may result in the appearance of plants which live in shaded regions of the desert and possibly animal species new to the area. The main point is that the solar-electric facility can be expected to change the local surface features. Consequently, if the site is located near to or adjacent to parks, wildlife preserves, etc., the scenic aspects should also be considered in the selection process. References 5-2, 5-3 and 5-4 provide further useful information on siting.

In summary, there are many candidate sites in the Southwest which appear to meet the general criteria for a large photovoltaic power plant. The site for this particular hypothetical power plant was chosen largely because of the availability of data pertaining to the particular area.

5.6 ALTERNATIVE SOURCES OF POWER GENERATION

General

Several alternative sources of power generation can be used for the Southwest. Among these are: (1) coal fired steam electric; (2) nuclear;

(3) hydroelectric; and (4) advanced methods other than solar. Each of these will be discussed in the following sections.

Coal Fired-Steam Electric

Among the conventional sources of power generation the use of coal is the most viable means for this region. Coal is available in quantity from nearby regions and can be transported to the facility via slurry pipeline, truck or rail. The slurry pipeline is gaining industry acceptance as a means of transport. However, for the Southwest this requires water, which is relatively scarce.

The principal limitation of a coal fired-steam electric plant important in the Southwest is the scarcity of cooling water. Design of a generating plant must ensure that no water is wasted and that water is recycled as much as possible. One means of accomplishing this is to recycle the slurry water and use it in the steam or cooling cycle. Another source, with which Nevada Power has substantial experience, is the use of secondary sewage effluent.

Typically the coal fired plant will consist of: (1) the power block; (2) a heat dissipation system; (3) coal handling and storage system; (4) emissions control; (5) electrical switching; (6) wastewater management; (7) liquid/solid waste handling and disposal; (8) lime supply and handling; (9) fuel oil; (10) dust abatement; and (11) noise abatement and sanitary waste.

In the most modern baseload plants, coal is converted into heat at nearly 90% efficiency. Turbo-generators then convert the thermal energy into electrical energy at an efficiency of approximately 45%. The station thus converts the thermal energy of coal into electrical energy at an efficiency of approximately 40%. However, additional coal is consumed to power the auxiliary systems and the dewatering plant if a slurry pipeline is used to transport the coal from the mines. The net energy available in the form of electrical power is thus reduced to approximately 38%.

A portion of the total energy in the coal will be expended to the environment during the energy conversion process. Expenditures include:

a. Waste heat to the environment through the stack in the form of thermal energy in the flue gases

b. Waste heat transferred to the atmosphere through the cooling towers

c. Energy expended through secondary sources such as thermal radiation and convection from piping and equipment. Thus also includes waste energy from the particulate and SO_2 removal systems.

Many of the plants in the Southwest are currently using or plan to extensively use treated municipal wastewater and reclaimed water from the coal slurry dewatering plants when these are used. The water is treated appropriately and stored in ponds to maintain a specified number of days' reserve. The ponds are lined with impervious native materials or synthetic water barriers to control seepage into the ground.

Compared with photovoltaic power generation, a coal fired plant creates air, water and thermal pollution directly, can inject water into the atmosphere, and requires coal mining.

The 30-year accrued land area dedicated to strip mining for coal may be 60 to 160% of the land needed for this specific photovoltaic power plant. This mined land is very difficult to reclaim, entirely aside from reconstituting its original contours. Surface water is adversely affected by siltation, acid mine drainage, and altered hydrologic features.

Mining is currently the second most dangerous occupation, with an annual fatality rate of 71 per 100,000. Deep mining requires (by comparison) only negligible land commitment, but is more dangerous and more expensive than strip mining.

Coal is a non-renewable resource. Although very extensive deposits remain to be exploited, its use cannot continue perpetually. Further, it is possible that the U.S. may need to dedicate much of its coal production to conversion processes and to petrochemicals production.

On balance, therefore, solar photovoltaic power generation seems preferable to coal environmentally, does not require the dedication of fossil fuel, and may be safer occupationally. Solar photovoltaic costs, however, remain completely non-competitive. To analyze the relative costs in the light of national goals is outside the scope of this project.

Nuclear Power Generation

Nuclear power plants are not particularly attractive for use in electrical power generation in those areas of the Southwest in which process water is difficult to appropriate. Consequently, in arid regions with high insolation typical of the sites where the first solar plants will be located, the nuclear plant is not necessarily attractive. Further, lead times to production of power are long (about 10 years) due to regulatory controls and public controversy.

Hydroelectric Power Generation

A hydroelectric plant is presently located near the hypothetical plant of this study. This plant is at the Hoover Dam on the Colorado River. The back-water from this dam forms Lake Mead. Because of the water requirements a hydroelectric plant is not a feasible alternative for the solar-electric plant when it is to be located in an arid region.

Advanced Energy Sources

A number of advanced energy conversion systems are currently being developed for use in the production of electrical energy. These include magnetohydrodynamics (MHD) and potassium topping cycles, high temperature turbines and direct conversion devices such as thermionic, thermoelectric, electrogasdynamic systems, and wind energy systems. Of these, the MHD topping systems in conjunction with regenerative steam cycles probably offer the most promise in the near-term for base load generation. The high temperature turbines may be used to meet peak power demands while the potassium cycle and the direct conversion devices may be used as topping cycles to improve the efficiency of the overall system.

The MHD generator produces electrical energy directly from high temperature thermal energy. The abundance of coal makes coal the most attractive fuel for the MHD generator with economics dictating the use of potassium as the seed material for the gas stream. The predicted efficiency of a combined MHD/steam turbine plant is in the range of 55 to 60%. This is nearly twice the efficiency of nuclear plants.

The effluent problems associated with these advanced energy systems (except for the wind powered systems) parallel those associated with the conventional energy conversion systems (i.e., fossil or nuclear). For coal-fired systems these include SO_2, NO_x, particulates and thermal. The advanced energy concepts in general have the potential to reduce thermal discharges and conserve fuel supplies when compared with the conventional power plants as a result of an improved energy conversion efficiency. Again the primary disadvantage is the need for water for cooling.

Wind-powered systems will probably find their earliest applications as suppliers of peak load needs for a network. The main requirement for the wind power device is a steady wind. It seems very unlikely that wind power stations can supply power in the quantities that we are discussing in the time scale in which this solar plant is to function. Further, wind power is site-specific. Suitable locations include the seacoast and the central plains, but probably not the desert Southwest.

5.7 CLOSER PACKING DENSITY FOR SOLAR MODULES

In the baseline plant concept, the solar modules are spaced on 32.9 m centers in a north-south, east-west rectangular grid pattern. This results in a total land area, for a 1000 MW output, of approximately 52 km^2 The major consideration in module spacing determination, other than mechanical clearance, is shadowing of one module by another. This is a prime tradeoff area since closer spacing results in a savings in land area as well as in interconnect cabling and access roads, but can cause plant power output losses and operational perturbations. To show the relationship between spacing (land area) and shadowing loss potential for the baseline plant, and to determine whether a land area reduction might be possible, a careful analysis was made to determine the specific angular criteria for shadowing to occur. Figure 5-1 shows how a typical module can shadow, in succession, modules to its west, northwest, north, northeast and east. Assuming level terrain, and using the baseline module dimensions and spacing, the following table gives the calculated solar azimuth/elevation boundary conditions for shadowing to occur:

TABLE 5-1. CONDITIONS FOR INTER-MODULE SHADOWING

Module Affected	Solar Azimuth Range (deg)	Solar Elevation (deg)
W	59 to 121	19.3
NW	114 to 156	12.7
N	149 to 211	19.[illegible]
NE	204 to 246	12.7
E	239 to 301	19.3

For the latitude of the selected plant site, which determines the apparent diurnal and seasonal movement of the sun, all shadowing occurs prior to 6:30 a.m. and after 3:30 p.m. (solar time) with the W and E shadowing occurring mostly before 7:30 a.m. and after 4:30 p.m. all year, and the N shadowing never occurring (at this latitude). The NW and NE shadowing can occur prior to 8:30 a.m. and after 3:30 p.m. but only during the winter months. When the north-south spacing is reduced from 32.9 to 24.4 m, the W, NW, NE, and E shadowing is virtually unaffected but N shadowing becomes severe during November and December, and during midday hours also. Although the yearly average energy loss would probably be less than 10%, the power fluctuations would not conform to normal operation of the utility grid and therefore would probably be unacceptable. This analysis indicates that although there is some potential for reducing the total land area occupied by the plant, by perhaps 10 to 15%, the acceptability of doing so will have to be determined by a detailed tradeoff study.

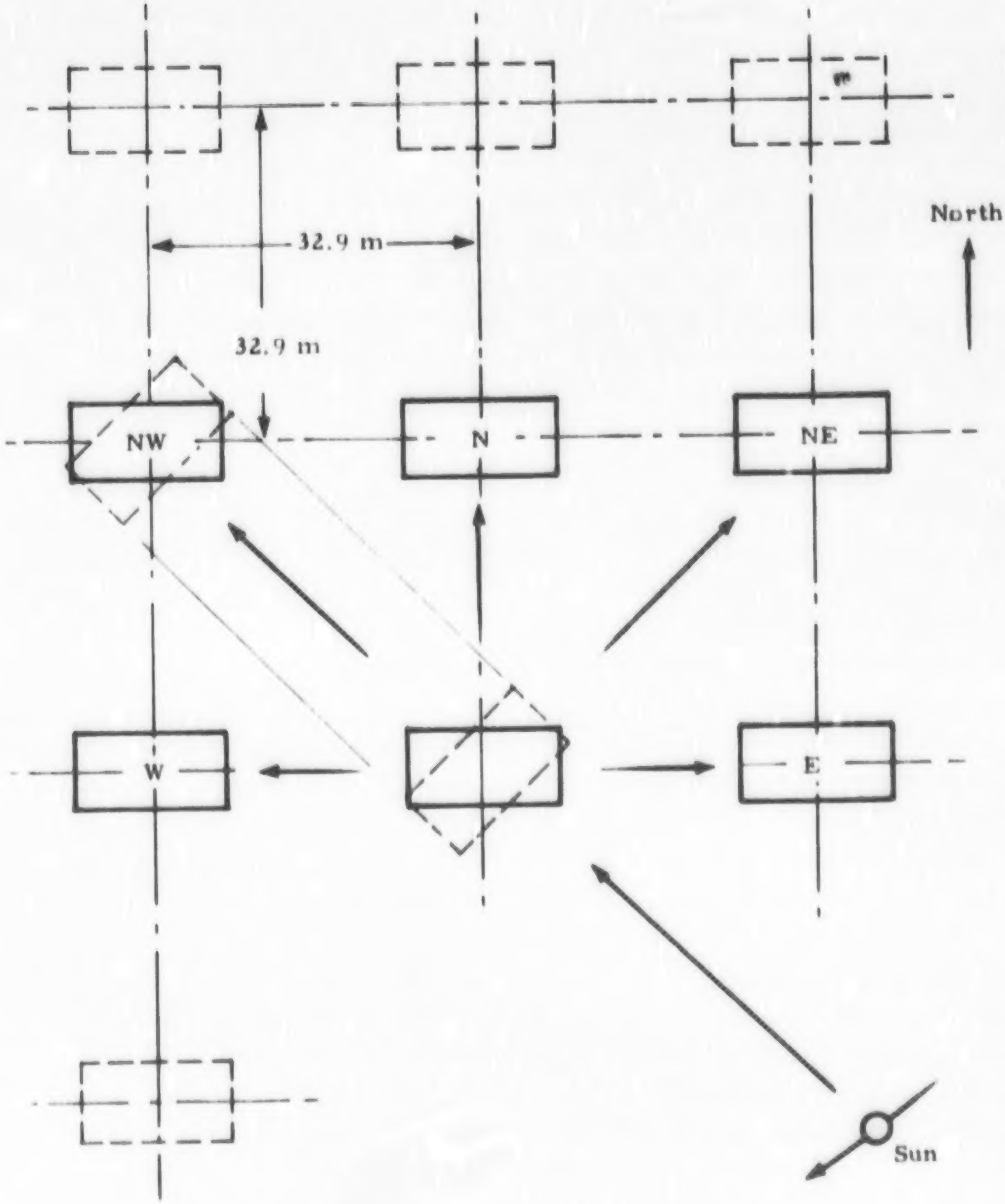
32.9 m
32.9 m
North
NW
N
NE
W
E
Sun

Fig. 5-1. Inter-module shadowing.

Because this hypothetical plant is sited on unused land without other productive potential, increased land use efficiency (at the expense of reduced generating capacity and output fluctuations) is probably not attractive.

5.8 OTHER SOLAR OPTIONS

For central station power generation, the major solar power options are the thermal-type plant using either a large number of distributed thermal collectors supplying heat to a central-receiver plant, or a central-receiving plant in which a large field of mirrors focuses solar heat onto an elevated receiver ("power tower") which in turn supplies heat to a steam-electric plant. Compared to a photovoltaic plant (which at present would cost significantly more) the thermal plants could have a substantially greater environmental impact since much more waste heat is released. The release is concentrated in the small area occupied by conventional cooling towers or ponds. Assuming a heat rate of 7600 Btu/kWhr for a solar steam electric plant, 1200 MW of power must be expended into the environment in cooling towers, ponds, or rivers. By comparison this photovoltaic plant would expend about 200 MW, primarily in battery houses distributed over 52 km^2

Cooling towers could be natural or mechanical draft. The noise emitted by the latter would not necessarily be audible at the facility perimeter. Wet towers would require water. However, Nevada Power (in whose operating area this hypothetical facility is located) has extensive experience using secondary sewage plant effluent for cooling water.

On balance, therefore, a solar thermal facility would create much greater potential thermal pollution problems, but would not necessarily require natural waters. Recycling would reduce the quantities of nutrient released to the environment. Cooling tower biocides and corrosion preventatives, drift, fog, and blowdown would be additional problems.

None of these problems are unique to solar steam electric power generation. A fossil or nuclear generating station would reject approximately comparable quantities of waste heat and the same cooling options would be applicable. Photovoltaic power generation, being a direct energy conversion process, is unique among currently envisioned technologies in that no central cooling facilities are needed and no substantial amount of heat rejection occurs.

Solar steam electric plants are projected to have greater overall efficiencies of conversion of total available insolation to bus bar power. Therefore, they are projected to require less land area for equivalent generating capacity. By itself this is not a compelling consideration because the current site is essentially non-productive waste land; capital equipment costs, rather than land costs, are the overriding concern.

5.9 STORAGE OPTIONS

No Storage

One alternative is zero energy storage capacity with the plant supplying power in accordance with available insolation. In addition to eliminating the cost of battery systems, the inverter equipment cost could likely be cut in half (with the regulator inputting power to simpler, undirectional inverters at a fixed dc voltage). This approach would result in a lower capital expenditure for the plant, but the plant would also be penalized by uncertain availability. This scheme might be acceptable if solar power represents a very small portion of the utility network's capacity and the loss of the plant's output due to transient cloud cover is not significant within normal fluctuations in a large system. However, if solar power is to contribute appreciable blocks of power to future utility networks, zero energy storage capacity will most likely be unacceptable (Ref. 5-5).

Lead Acid Batteries

Although well developed and proven, the familiar lead-acid battery is not considered competitive with the new lithium-sulfur cells for the following reasons: Energy density is significantly lower, which would require a much greater mass of battery material; the lead-acid battery is wasteful of lead which could come into short supply; high charging rates cause boiling and

H_2 evolution and high discharge rates cause electrode pitting. For these reasons it is believed that the total annual cost of a lead-acid battery storage system would be considerably higher than the lithium-sulfur system, with no environmental advantages.

Pumped Hydro Storage

The use of pumped hydro storage would require a high reservoir and a low reservoir plus the necessary pumping and generation equipment. Cost considerations usually require that the natural geography be suitable for such a storage system. For the sites considered, the closest available reservoir is Lake Mead. The use of Lake Mead would require that a reservoir be built at a nearby site at a higher elevation. It is believed that such a facility would have a greater environmental impact than battery storage technique. For this reason, pumped hydro storage is not considered a viable alternative.

Hydrogen Cycle Storage

A hydrogen cycle storage system, which would consist primarily of electrolysis cells, fuel cells, and a suitable hydrogen facility, in an attractive alternate to the use of batteries and has been considered by various utilities for load-leveling applications. At present, however, the projected cost per kilowatt is higher and the overall turnaround efficiency is considerably lower which further impacts total cost. For this reason, this storage method is not considered a viable alternative this early in the development of the solar-electric industry.

5.10 CONCLUSIONS

In conclusion, the proposed (hypothetical) photovoltaic power plant with battery storage has several possible alternatives with regard to energy conversion and storage, but appears to be justifiable with regard to conservation of national energy resources and minimization of environment disturbance caused by the large scale generation of electrical power.

5.11 REFERENCES

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SECTION 6

PROBABLE ADVERSE ENVIRONMENTAL EFFECTS WHICH CANNOT BE AVOIDED

6.1 ECOLOGICAL EFFECTS

by W. Glen Bradley

As described previously in Section 4.1 (Ecological Impacts), severe damage will occur to the soil surface, vegetation, and associated wildlife during construction. Due to the solar-electric site design, which requires placement of solar modules at short distances from each other, there may be no way to avoid removal of most of the perennial vegetation and disruption of much of the soil surface during the varied construction activities such as heavy equipment movement, leveling, filling, and drilling. It must be recognized that this is an extremely adverse effect which will increase soil erosion by both wind and water and the establishment of vegetation not native to the area. Both soil stabilization and vegetative recovery will be an extremely slow process requiring decades or possibly a century (6-1 and 2). It should be further realized that even with mitigative measures the area may not reestablish vegetative cover and soil surface approaching natural conditions within the lifetime of the solar-electric plant. In fact, it is possible that pristine desert vegetation may never occur on the area again.

The characteristic desert vertebrate fauna found on the area will be disrupted by removal of shelter, habitat, and food resources. Burrowing animals, in particular, will experience high mortality and loss of shelter during soil movement phases of construction. Additionally, there will be dispersal of most vertebrate species into areas of similar habitat adjacent to the construction site. Reestablishment of viable vertebrate population after plant construction will be dependent upon the rate of reestablishment of vegetation and soil stabilization. Vertebrate species composition and density during the extremely long period of vegetative recovery will be dif-derent than that originally occurring on the area.

Only two species, the Desert Tortoise and the Kit Fox, which are on the threatened and protected list of Nevada, occur in the area. High mortality is to be expected for the Desert Tortoise due to destruction of burrows which are used both as shelters and hibernals. This will be accompanied by dispersal of the remaining Desert Tortoises to adjacent areas surrounding the solar-electric sites. Little or no mortality is to be expected for Kit Fox populations which have wide ranging activity patterns. Population dispersal will be into adjacent areas, and reestablishment on the area will be dependent upon population density of prey, such as rodents and rabbits.

6.2 VISUAL EFFECTS

The most obvious effect of this installation would be its visual impact. Stretching for many miles within full view of traffic on Interstate 15 and US 93, the project will conform exactly to the public concept of solar energy as requiring commitment of vast land areas.

This visual effect is unavoidable at the proposed siting (Units 1 and 2). It would be nearly as obvious in the alternative siting.

This visual effect may be undesirable if it causes the public to perceive solar energy development as a threat to land values.

6.3 LOST RECREATIONAL VALUES

The only possible recreational uses of this site of which we are aware are possible use for:

- Off-road vehicle touring and competition
- Amateur archaeological and historical artifact collecting.

Both of these activities are currently discouraged, controlled, or even prohibited on some Federal lands. They are considered undesirable and destructive by many authorities. The loss due to this project is unavoidable. Some sectors of the public may regard this loss as adverse.

6.4 SOCIO-ECONOMIC EFFECTS

Numerous social, demographic, economic, and community effects will occur, that are beyond the scope of this task to analyze. As indicated briefly in Section 4.13, all of these effects are thought to be very small viewed in the light of projected growth for this region.

A possible exception is the demands placed on the skilled crafts manpower pool of the area, in which manufacturing and construction are not prominent.

The project is expected to cause an influx of skilled craftsmen who might experience difficulty finding local employment after the project is complete.

6.5 ATMOSPHERIC EMISSIONS

Fugitive dust emissions are anticipated due to grubbing, grading, and vehicular traffic on unpaved terrain. While dust suppressants can be applied, it is not economically feasible to prevent all dust emissions. Using modern construction engineering practices, it will be possible to comply with current Clark County, Nevada, and USEPA fugitive dust regulations (of Section 1.5).

6.6 REFERENCES

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6-2. Wells, P. V. Succession in Desert Vegetation on Streets of a Nevada Ghost Town. Science, 134: 670-671, 1961.

SECTION 7
MITIGATION OF AVOIDABLE IMPACTS

7.1 ECOLOGICAL IMPACTS
(by W. Glen Bradley)

Reestablishing Vegetation

Potential mitigative measures are numerous and varied and are dependent largely upon the monetary expenditure provided during plant construction and early stages of plant operation. It is highly recommended that a professional ecologist be employed prior to site construction. This person sould be responsible for development of an overall plan for mitigative measures to be employed during plant construction and operation. This would not only allow mitigation of avoidable impacts but reduce the intensity of unavoidable ecological effects during construction.

Plans should be developed prior to construction which will allow minimal disruption of soil surface and removal of perennial vegetation. It is realized that these plans will have to be developed in coordination with construction engineers within the general framework of what is technologically and economically feasible. It is extremely important, however, that widely distributed islands of intact perennial vegetation remain on the area after construction to provide seed reserves for vegetative recovery. This would retard soil erosion. Resulting hazards of brush wildfire need to be monitored continuously.

Installation of microcatchment basins for water and reestablishment of vegetation has been used in Israel (Ref. 7-1). For example, in one study it was found that a 500 m^2 basin produced optimum retention; when basin size was reduced so was moisture retention and vegetative recovery.

The distance between the circles swept out by module corners is 13.05 m. An 8 m catchment basin would have an area of 50 m^2, and would leave a 2.5 m vehicle passage (on each side) between its rim and the nearest corner of a module. Although only 10% of the basin area found necessary in the Israeli study, such shallow depressions (perhaps only 0.6 m deep), would greatly increase chances of recovery of vegetation.

Revegetation of basins could be a combination of transplanting of desert shrubs and seeding by artificial or natural means. It is strongly recommended that initial attempts be made to transplant native shrubs into the catchment basin to aid in natural recovery. Plant construction will be in phases. In each area, shrubs can be removed during construction and transplanted to previously developed areas. It is recognized that construction of basins and transplanting of native shrubs would involve considerable expenditure of manpower and funds. This mitigative measure, however, would provide maximal opportunity for reestablishment of native vegetation at a more rapid rate and greatly enhance the possibility of establishment of vegetation which would retard soil erosion and promote soil stabilization. (cf. our earlier discussion of shading and rainfall spalsh effects.)

Hydromulching or hydroseeding is a method of application of seed into soil by high pressure water spray (Ref. 7-2). This technique has recently been developed and is in use for seeding slopes of newly constructed highways. Seed, fertilizer and nutrients are mixed together in a slurry. The slurry is mixed in holding tanks and then sprayed by use of high pressure pumps onto the soil surface. Various mulches can be used, including straw held together by oil, or more recently wood fibers or fiberglass in a light resin. Although hydroseeding has usually involved sowing grass seeds, the technique is adaptable for seeding native plant species, both herbaceous and perennial. Seeds of native shrubs and herbs may be obtained commercially and in large quantities by special order (Ref. 7-3). A mixture of herb and shrub seeds is recommended for hydroseeding. This would promote establishment of a variety of native species on the area. Germination requirements, particularly soil moisture and temperature, are highly variable between plant species. Use of a variety of native seeds would increase the probability of successful germination, establishment, and development of plant cover. Large scale application of these methods should be preceded by on-site test plot experiments.

Seeding should occur in fall and winter months to take advantage of the cooler temperature and available soil moisture. Additionally, the cooler temperatures during this period are important in breaking seed dormancy. Some native species, however, may have to be treated with sulphuric acid or mechanical rubbing for seed scarification to promote germination. Transplanting of desert shrubs is most successful in the spring, especially if adequate soil moisture is present. A major problem commonly experienced in seeding and transplanting in arid regions is damage to seedlings or transplants by rabbits or rodents. Various poisoning programs have been used in the past to effectively control damaging populations of these animals. In recent years, government regulations have largely prohibited the use of poisons to control animal populations. If this problem occurs during reestablishment of vegetation, effective control of rodent populations can be achieved through intensive snap-trap programs for selected areas. Rabbits can be effectively controlled by nighttime hunting from vehicles using spotlights when permitted by game laws.

Soil erosion and removal of perennial vegetation are the most prominent adverse environmental effects which would occur on the area during construction and be maintained throughout plant operation. It is strongly recommended that mitigative measures involving minimal destruction of perennial vegetation and soil surface, development of microcatchment basins accompanied by transplanting of perennial vegetation, and hydroseeding throughout the solar-electric sites be employed. These measures would greatly reduce soil erosion by speeding up the processes of soil stabilization and vegetative recovery. They would also greatly enhance the rate of vegetative reestablishment, reduce the intensity of invasion by weed species, and increase the probability for the successful reestablishment of native plant species.

Minimizing Impacts of Construction on Animal Populations

Previous discussion has indicated that animal populations will be affected to varying degrees by construction activities which will deplete shelter and food resources and destroy burrows and hibernals. Relatively high mortaility is to be expected for burrowing animals such as rodents, lizards, snakes, and Desert Tortoises. This is particularly true during periods of hibernation. It is not practical to consider measures to reduce mortality for most burrowing animals except possibly to concentrate soil moving activities during spring, summer, and early fall. Special measures should be taken to minimize mortality of Desert Tortoise populations since it is on the list of the threatened species as established by Nevada Fish and Game. All burrows should be located immediately prior to construction and checked for occupancy. Desert Tortoises should be removed and relocated to suitable habitat outside the area with cooperation of Nevada Fish and Game. This procedure is absolutely necessary during colder months of the year when tortoises will be located within hibernal burrows. In many instances, these are of sufficient size that they will have to be excavated to determine occupany.

The major mitigative measures to minimize long-term damage to animal populations have been described previously in the section, "Reestablishing Vegetation." As soil stabilization and revegetation occurs, most species will disperse and reestablish themselves on the solar-electric sites.

Conclusions

Mitigative measures have been proposed to accelerate successional sequences leading to the reestablishment of native vegetation and soil stabilization. In addition, it is recommended that Desert Tortoise be removed and relocated prior to construction. Mitigative measures recommended to achieve the above objectives include the following: (1) employment of a professional ecologist to develop procedures for minimal destruction of soil surface and perennial vegetation during construction; (2) promote vegetative recovery and soil stabilization by requiring intact islands of perennial vegetation to be preserved on the sites, development of microcatchment basins, transplanting of perennial shrubs, and hydroseeding of native herb and shrub species throughout the solar-electric sites; and (3) relocation of threatened Desert Tortoise populations in cooperation with the Nevada Fish and Game.

7.2 SOCIO-ECONOMIC IMPACTS

As discussed earlier, it is proposed to actively discourage development of construction villages, and actively encourage contractor and subcontractor employees to live in the Las Vegas urban area or in Moapa Valley. Among mechanisms for doing this are to:

- Establishment of a commuter bus service from Las Vegas.
- Coordination with realtors in the Las Vegas area.

7.3 ATMOSPHERIC EMISSIONS

Plastic reflector substrate suffering photolytic or thermal degradation is likely to emit gaseous products (cf. Sections 1.2 and 4.5). As indicated previously, material exhibiting significant degradation is economically undesirable, and therefore is not likely to be chosen deliberately. To forestall inadvertent selection of an undesirable material, we suggest that an active R&D program be pursued. This should include accelerated life tests as well as spectroscopic and gas chromatographic studies of exposed plastic and emissions generated, respectively.

A program of dispersion modeling for this large distributed (class B) source is desirable ultimately, but probably premature at this time.

7.4 REFERENCES

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7-3. Native seeds can be obtained commercially from the following companies: Environmental Seed Producers, Inc., P. O. 1196, El Monte, California, 91734 and/or Peacoff Brothers Nursery and Seed Company, Route 5, Box 215-R, Escondido, California, 902025.

SECTION 8

RELATIONSHIP BETWEEN LOCAL SHORT-TERM USE OF MAN'S ENVIRONMENT AND THE MAINTENANCE AND ENHANCEMENT OF LONG-TERM PRODUCTIVITY

8.1 LAND USE BENEFITS

At the present time there is no productive utilization of the land proposed for Units 1 and 2. Soil conditions preclude use for agricultural purposes even with irrigation. There is one mining claim, of unknown value and validity, on this land near U.S. Highway 93 about 1.6 km from U.S. Interstate 15. Therefore, the principal attributes of this land are its topography and its proximity to already existing transportation and power transmission corridors.

The proposed hypothetical land use is an unusually appropriate means to convert this land to productivity because of the site's geographical location with respect to load centers, its climate and insolation, and because the proposed project requires no process water whatsoever.

8.2 DECOMMISSIONING

Decommissioning of the plant would involve dismantling and salvaging all module structures for scrap value, and removal of all plant facilities except subgrade foundations and some of the buildings.

We assume that a replacement generating station will have been built somewhere – prior to decommissioning of this facility. Continuing projected load growth in this region will probably require additional generating capacity however. This site, after removal of residual structures, will continue to be unusually suitable for siting of facilities not needing process water – particularly solar photovoltaic installations. After decommissioning, the land wil be cleared, graded, and left with internal roads, rail and highway access, security fence and a few residual buildings. Therefore, it will have enhanced value also as an industrial site.

8.3 POWER CONTRIBUTION

This project is expected to supply about 7% of the utility system's projected generating capacity in the late 1980s. Over the 30-year projected life of this facility, 26×10^9 kWhr of electricity will be generated assuming an 0.50 capacity factor. This will be consumed largely in Las Vegas and Los Angeles. Las Vegas alone consumed 4.2×10^9 kWhr in 1974, or about 11×10^3 kWhr per capita. Projected population growth exceeds 16,000 annually. At current electricity consumption, this corresponds to an annual demand growth of 176×10^6 kWhr (or 4.2% of 1974 consumption) or 5.3×10^9 kWhr over 30 years.

8.4 TAX REVENUES

Property Taxes

Based on 1976 dollars, a total capital cost of $\$1.67 \times 10^9$ is projected for the hypothetical plant. Construction is to be phased and segments of the plant are to go on line as constructed. Estimated property taxes (Table 8-1) are calculated assuming a linearly increased investment and assessed value over 10 years, 30 years operation at 3% depreciation, and 5 years linear reduction to zero value.

Sanitation District Payments

The estimated 23 m^3/day requirements for potable water (including visitor center needs) amount to 8300 m^3/yr. Water will be purchased from Clark County at \$81.37/10^3 m^3 or \$674/yr, a trivial contribution to county finances.

For the required 8×10^5 m^3 construction concrete, 1.4×10^5 m^3 water will be required. This will be the responsibility of the concrete batcher. Even if potable water were used, this would represent only a

TABLE 8-1. ESTIMATED PROPERTY TAX REVENUES FROM PROPOSED SOLAR-ELECTRIC STATION ($ MILLIONS)

Year After Go-Ahead	Depreciated Value @ 3%	Assessed[*] Valuation	Property Taxes[**] Clark Co.[+]	Property Taxes[**] Nye Co.[++]
0	0	0	0.0	0.0
5	835	292	13.00	0.112
10	1670	585	26.04	0.225
15	1434	502	22.34	0.193
25	1231	431	19.18	0.166
30	1057	370	16.47	0.142
35	908	318	14.15	0.122
40	450	158	7.03	0.061
45	0	0	0.0	0.0

[*] 35% of actual valuation.

[**] Allocated by single-wire-mile method, 98.9% to Clark County, 1.1% to Nye County.

[+] $4.50/$100.

[++] $3.50/$100.

$11,090 total payment to the Clark Co. Sanitation District, or an additional $1400/yr. during the foundation preparation phase. This represents a trivial contribution to the Clark County economy.

8.5 OTHER ECONOMIC BENEFITS

Employment and Income

Peak direct employment during construction will be about 1000, with potential secondary induced employment of 1600.

Significant numbers of the construction workers will come from outside the county, but will live and pay taxes in Clark County during their employment. Operating personnel and secondary induced employment totalling about 130 persons, represent a small contribution to the workforce in Clark County. The annual construction payroll would peak at about $\$14 \times 10^6$.

Other Financial Sectors

It is beyond the scope of this task to estimate the impact of this workforce and the construction project investments upon retail trade and other economic sectors. The effect will be significant, but in general all economic effects will be dwarfed by the county's projected growth (without the project) for the remainder of the century.

8.6 COSTS

Incremental Community Services and Facility Costs

These costs are estimated by assuming the basic accuracy of the costs projected in the Harry Allen assessment (Ref. 8-1) and scaling those costs assuming they are linear with workforce. During the peak workforce years, approximately 2 to 9 years after go-ahead, the incremental costs are indicated in Table 8.2.

TABLE 8-2. INCREMENTAL COMMUNITY COSTS FOR SERVICES AND FACILITIES

Service	$\$ \times 10^3$
Schools	263
Sewer	15
Water	55
Police	82
Fire	46
Solid Waste	11
Total	472

Environmental Costs

As discussed in Sections 2.9, 4.1, 6.1 and 7.1, there will be some direct and indirect ecological effects, but no species are expected to be endangered or threatened. Inevitable losses of vegetation followed by partial regrowth of different vegetative cover will possibly lead to long term or permanent reductions in numbers of some vertebrate and invertebrate species on the site.

No long-term adverse effects on either atmospheric or water quality can be identified. No significant thermal pollution is created.

Visual (aesthetic) effects will be inevitable and long term. Not all observers will regard them as adverse, but many will. Because the land proposed for use is wasteland described as having below average scenic value, actual "visual costs" (if they could be quantified) would be minor.

Recreational Costs

The current use of this land for major off-road vehicle competitions would be precluded by installation of the solar electric plant. Such use would need to be prohibited even on adjacent areas, in order not to adversely increase the dust burden on solar collectors.

Mineral Extraction

The one mining claim extant, the Old Witch Mine, is of unknown value. The Bureau of Land Management has not yet investigated or validated the claim. Even should the claim be validated and a mine established, this would not necessarily conflict with the proposed action if operators use shaft or drift operation. No independent field analysis of the mineral potential of this area was done for this report.

8.7 REFERENCE

8-1 Nevada Power Company. Environmental Assessment, Allen Warner Valley Energy System, Volume III Harry Allen Station, September 1975; and Appendices Volume to Volume III, September 1975, Las Vegas, Nevada.

SECTION 9

IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES INVOLVED IN THE PROPOSED ACTION

9.1 SILICON

Production of arrays which will put out 1000 MW (peak) using 0.15 mm thick, 20% efficient, silicon solar cells with overall production yield of 34.8% requires 5×10^6 kg of pure polycrystalline silicon. This is less than four times the estimated total semiconductor silicon production in 1974 and about 6% of the 1968 United Sates production of 99% pure silicon (metallurgical grade). The U.S. reserves of SiO_2 which may be used to produce silicon are so great that they have not been completely catalogued. The level of utilization of silicon solar cells is limited by economics--not by resource availability (Ref. 9-1).

9.2 STEEL

Steel requirements are listed in Table 9-1, and compared with supply/demand data in Table 9-2. The station requirement of 835×10^6 kg steel (almost 10^6 tons) is seen to represent a small fraction of U.S. reserves. Spread over seven or eight years, the station requirements would represent only a trivial amount of U.S. production.

9.3 CEMENT

Station requirements are about 260×10^6 kg of cement, or about 32×10^6 kg/yr. By comparison, the neighboring Apex plant of U.S. Lime Products Division, Flintkote Company, produces about 450×10^6 kg of calcined lime annually. Other raw materials in Portland cement production are equally abundant.

TABLE 9-1. STEEL REQUIREMENTS FOR 50,000 MODULE ARRAY*

Component	Steel, kg	
	Per Module	Entire 1000 MW Array
Rotating Structure		
Collectors	7285	—
Superstructure	4898	—
Wheels and Pillow Blocks	531	—
Connectors and Fasteners	381	—
Subtotal	13096	655×10^6
Substructure and Foundations		
Center Support (including rebar)	767	—
Track Assembly	2845	—
Subtotal	3612	181×10^6
Total Steel	16709	835×10^6

*Ref. 9-2.

TABLE 9-2. STEEL SUPPLY/DEMAND DATA* COMPARED WITH STATION REQUIREMENTS

Datum	Steel, 10^6 kg
Station Requirements	835
U. S. Reserves	2,000,000
U. S. Annual Consumption	128,000
World Production	574,000

*Ref. 9-3.

9.4 WATER

Construction water is needed principally for concrete production. Requirements are about 1.4×10^5 m^3. Although its transport is costly, water is available.

9.5 COAL

Coal is required to produce metallurgical coke, used in both silicon and steel production. The 1000 MW of generating capacity of solar cells will require only about 70×10^6 kg coal, assuming 70% coking yield (Ref. 9-1).

9.6 LITHIUM

Battery storage units require approximately 2.4×10^6 kg lithium. U. S. production in 1974 was 3.4×10^6 kg, with rest-of-world production 1.6×10^6 kg. Assuming installation over approximately eight years, batteries for this plant would represent about 10% of 1974 annual production each year for eight years. One estimate of U.S. reserves is less than 10^9 kg; industry estimates are much more optimistic (Ref. 9-4). Lithium may be demand limited if major competing uses develop (e.g., nuclear fusion or electric vehicles).

9.7 OTHER

Human resources and land commitment have been discussed in some detail previously. Basically, the human requirements are small, and occur partly in crafts beset by chronic unemployment.

Land resource commitment is large, especially if projected to the day when 10^6 MW are generated by solar electric plants. However, this particular hypothetical plant is sited on wasteland where principal current use is destructive recreation (off-road racing).

9.8 REFERENCES

9-1. M. G. Gandel, P. A. Dillard, D. R. Sears, S. M. Ko and S. V. Bourgeois, Assessment of Large Scale Photovoltaic Materials Production, LMSC-HREC TR D497252, Lockheed Huntsville Research & Engineering Center, Huntsville, Alabama, July 1976.

9-2. Davidson, Joseph K., and H. Lundgren. Letter report to Spectrolab, Inc., on a "Conceptual Design of a Photovoltaic Central Station Power Plant (Module)," Ingenasu Associates, Tempe, Arizona, May 1976.

9-3. U.S. Nuclear Regulatory Commission. Draft Environmental Impact Statement, Palo Verde Nuclear Generating Station, Washington, D.C., April 1975.

9-4. Hammond, A. L. Lithium: Will Short Supply Constrain Energy Technologies? Science, Vol. 191, 1976, p. 1037.

SECTION 10

INTERESTS AND CONSIDERATIONS OF FEDERAL POLICY THOUGHT TO OFFSET THE ADVERSE ENVIRONMENTAL EFFECT

It is beyond the scope of this task to analyze the relevant Federal policies. The following list contains those thought to be most significant or most relevant:

- To develop increased independence from imported fuel supplies, by developing non-resource depleting domestic energy supplies
- To maintain air quality standards by avoidance of fossil fuel combustion
- To avoid further appropriation and deterioration of natural waters — particularly those subject to international agreement (the Colorado River) and those in arid regions (South Nevada)
- To improve the productivity of lands now lying waste
- To improve the U.S. balance of payments by avoiding fuel imports
- To emphasize utilization of regenerable resources (e.g., sunlight)
- To encourage private-sector employment in trades or geographical areas suffering chronic episodes of high unemployment

SECTION 11

SECONDARY IMPACTS

11.1 POLLUTIONAL EFFECTS OF THE SILICON SOLAR CELL MANUFACTURING INDUSTRY

In a companion report (Ref. 11-1), Gandel et al have examined the environmental problems associated with photovoltaic-grade silicon and silicon solar cell manufacture. These authors identify the following pollutant releases:

- Indirect pollution resulting from large power consumption in Si and cell production
- SiO dust of unknown particle size distribution
- Si dust of unknown particle size distribution
- NO_x and SO_2
- SiF_4 (and hence H_2F_2)
- Air and water pollution from coking, coke pushing, and coke quenching
- Airborne SiC dust of unknown particle size distribution
- Disposal of cutting sludges containing oils, clays, abrasives, adhesives, and inert metals
- Disposal of scrubber sludges, containing $Ca(OH)_2$ and CaF_2.

The same report contains material balances for most of the raw materials and identifies some additional waste streams. Total power consumption of a production facility producing finished cells starting with quartzite is about 1 MW for every megawatt's worth of annual production of generating capacity. That is, to say, the factory producing in one year the cells for this hypothetical 1000 MW solar power plant would consume energy at the rate of 1000 MW (three shift operation).

11.2 SOCIO-ECONOMIC EFFECTS

Socio-economic and community effects are discussed briefly in Section 4.13. It was beyond the scope of this task to present an analysis in the depth needed to evaluate secondary consequences. It is suggested, however, that the reader examine the Harry Allen assessment to study in some detail the effects of a major power plant project on demographic, socio-economic, and community characteristics in extreme southern Nevada. Scaling of work force, capital requirements, and power contribution, and adjustments in the timing and manpower loading analysis would be required.

11.3 EFFECTS ON TRANSPORTATION SYSTEMS

This project would place major demands on transportation systems, especially highway and rail. Similar demands would be created by 1000 MW solar steam-electric plants, which are likely to be built before photovoltaic plants.

We recommend that an analysis of the impact of solar generating stations on traffic systems precede actual plant construction with ample lead time to effect the needed expansion or modifications in these systems.

11.4 REFERENCE

11-1. M. G. Gandel, P. A. Dillard, D. R. Sears, S. M. Ko and S. V. Bourgeois, "Assessment of Large Scale Photovoltaic Materials Production," LMSC-HREC TR D497252, Lockheed-Huntsville Research & Engineering Center, Huntsville, Alabama, July 1976.

SECTION 12

COORDINATION

Many agencies and contractors were consulted during the course of this study. The following personnel supplied reports or other information critically important to this project or granted release to use and quote unpublished material. They are listed in approximate chronological order.

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Appendix A

CONVERSION FACTORS

The bulk of this report uses metric units rather than English. However, American practice in the electrical utilities industry, public land records, and finance remains non-metric. The following tables will assist the reader in necessary conversions.

TABLE A-1. METRIC-TO-ENGLISH CONVERSION FACTORS

To Convert From	To	Multiply by
Kilometers	Miles	0.6215
Meters	Feet	3.279
Kilometers/hr	Knots	0.5400
Hectares	Acres	2.469
Kilograms	Pounds	2.205
Kilograms	Tons	1.102×10^{-3}
Cubic Meters	Cubic Feet	35.34
Cubic Meters	Cubic Yard	1.307
Cubic Meters	Gallons	264.20
Cubic Meters	Acre-Feet	2.296×10^{-5}
Abs. Joule $\sec^{-1}$ (Watts)	Horsepower	1.340×10^{-3}
Abs. Joule	kWhr	2.778×10^{-7}

TABLE A-2. ENGLISH-TO-METRIC CONVERSION FACTORS

To Convert		
From	To	Multiply by
Miles	Kilometers	1.609
Feet	Meters	0.305
Knots	Kilometers/hr	1.852
Acres	Hectares	0.405
Pounds	Kilograms	0.4536
Tons	Kilograms	907.2
Cubic Feet	Cubic Meters	0.0283
Cubic Yard	Cubic Meters	0.765
Gallons	Cubic Meters	3.785×10^{-3}
Acre-Feet	Cubic Meters	43560
Horsepower	Abs. Joule sec^{-1} (Watts)	746
kWhr	Abs. Joule	3.6×10^{6}

Appendix B

GLOSSARY OF TERMS AND ABBREVIATIONS

ac	alternating current
Array	the 52 km^2 assembly of 500 groups (50,000 modules)*
BLM	Bureau of Land Management
Breeze	airborne coal dust
CF	capacity factor = ratio of energy actually produced to maximum amount possible, over period of operation
Collector	a single parabolic trough primary supporting a single Winston secondary containing a string of photovoltaic cells (inset, Figure 1-3)*.
dc	direct current
EPA	Environmental Protection Agency
Group	an electrically interconnected set of 100 modules (Figure 1-2)*.
GW_e	gigawatt electric = 10^6 kW (see MW_e)
Heat Rate	fuel heat input required to generate a kWh. Commonly expressed in Btu/kWh
MSL	mean sea level
MT	metric ton = 10^3 kg
MW_e	megawatt electric (10^3 kW electric power actually produced as distinct from heating value of fuel consumed)
NPDES	National Pollution Discharge Elimination System
PCM	power conditioning module. The pair of buildings comprising battery storage, regulator, and inverters, etc., servicing one group of 100 modules (Figures 1-5 and 1-6)*.
SCR	silicon controlled rectifier
Solar Module	a single sun-tracking, rotating structure, containing 14 collectors (Figure 1-3)*.
Unit	one of the two geographically separated sections of the plant (Figure 2-1)*.

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*Definition specific to this report. May not apply in other contexts.